**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

# Note to Reader

**Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply. EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.**

**The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, If unacceptable risks are identified, EPA will act to reduce or eliminate the risks.**

**There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.**

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

**Note:** This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket ( RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

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## 4. Ecological Risk Characterization

### a. Summary of Risk Assumptions

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** - potential for acute risk is high and regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high and regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD50 (birds and mammals (3) EC50 (aquatic plants and aquatic invertebrates) and (4) EC25 (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates) (2) NOEC (birds, fish and aquatic invertebrates) and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC value is used as the ecotoxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Risk presumptions, along with the corresponding RQs and LOCs are tabulated below.

Risk Presumptions for Terrestrial Animals

| Risk Presumption | RQ | LOC |
|---|---|---|
| Birds and Mammals | | |

Risk Presumptions for Terrestrial Animals

| Risk Presumption | RQ | LOC |
|---|---|---|
| Acute High Risk | EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3] | 0.5 |
| Acute Restricted Use | EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg) | 0.2 |
| Acute Endangered Species | EEC/LC50 or LD50/sqft or LD50/day | 0.1 |
| Chronic Risk | EEC/NOEC | 1 |

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] $\frac{mg/ft^2}{LD50 * wt. of bird}$ [3] $\frac{mg\ of\ toxicant\ consumed/day}{LD50 * wt. of bird}$

Risk Presumptions for Aquatic Animals

| Risk Presumption | RQ | LOC |
|---|---|---|
| Acute High Risk | EEC[1]/LC50 or EC50 | 0.5 |
| Acute Restricted Use | EEC/LC50 or EC50 | 0.1 |
| Acute Endangered Species | EEC/LC50 or EC50 | 0.05 |
| Chronic Risk | EEC/MATC or NOEC | 1 |

[1] EEC = (ppm or ppb) in water

Risk Presumptions for Plants

| Risk Presumption | RQ | LOC |
|---|---|---|
| | Terrestrial and Semi-Aquatic Plants | |
| Acute High Risk | EEC[1]/EC25 | 1 |
| Acute Endangered Species | EEC/EC05 or NOEC | 1 |
| | Aquatic Plants | |
| Acute High Risk | EEC[2]/EC50 | 1 |
| Acute Endangered Species | EEC/EC05 or NOEC | 1 |

[1] EEC = lbs ai/A
[2] EEC = (ppb/ppm) in water

### b. Summary of Risks to Nontarget Organisms

Terrestrial and Aquatic Field Studies Demonstrate Adverse Effects to Non-target Organisms

Three extensive terrestrial field studies on corn in Iowa, citrus in California, and golf courses in central Florida, report cholinesterase-inhibition effects and chlorpyrifos-related mortality in non-target organisms. Chlorpyrifos-related mortalities were reported in small mammals, birds, snakes, an aquatic turtle, and amphibians as determined by measureable chlorpyrifos residues in the carcasses. Other non-target organisms were observed showing behaviors indicative of cholinesterase inhibition. And although these field studies did not include an aquatic application

or require monitoring of aquatic areas, fish kills were reported in the citrus and golf course studies in aquatic habitats adjacent to treated areas.

Measured chlorpyrifos levels on foliage samples and water samples reported in all three studies generally exceed the EFED predicted, foliar and aquatic EECs for respective yapplication rates. These chlorpyrifos residue levels also exceed the $LC_{50}$ and/or $EC_{50}$ values for mammals, birds, fish and aquatic invertebrates.

Aquatic field studies where chlorpyrifos has been applied directly to water for insect control have shown adverse effects on non-target species, including fish recruitment and growth and near elimination of some aquatic invertebrate populations. Chlorpyrifos-related mortalities identified in the three field studies confirm estimates of high risks to both terrestrial and aquatic wildlife from chlorpyrifos uses.

Incident Records Confirm Adverse Effects to Non-target Organisms

Incident reports indicate song bird kills and occasional fish kills mostly associated with termite applications, particularly perimeter treatments. Wildlife incidents associated with lawn care treatment with chlorpyrifos for soil insect control include the deaths of robins, starlings, sparrows, geese, goslings, a bluebird, a cat, and fish. In some cases, other pesticides, such as diazinon, are also present. Huang *et al*. (1994) conclude that the toxicity of chlorpyrifos and diazinon are additive (not synergistic) to aquatic organisms. Toxicity of two chemicals A and B are additive, if the concentrations of [A] and [B] yield increased toxicity, such that $1/[LC_{50}$ of AB] = $1/[LC_{50}$ of A] + $1/[LC_{50}$ of B]. In most incident cases, the lawns had been sprayed with a liquid formulation of chlorpyrifos. The largest wildlife incidents are associated with 15-foot wide, perimeter treatments following termiticide treatments of buildings. Approximately 75 robins were killed in a single incident in Daytona Beach, FL; 32 robins were killed in Tennessee; and 24 robins were killed in Georgia. Fish kills have also been reported for termite control treatments. In one incident 2,000 small bluegill sunfish were killed in a lake adjacent to two motel rooms which had been treated for termites. The use of chlorpyrifos on golf courses has been associated with the deaths of 35 geese in one incident and 8 geese in another. In some cases, another pesticide like diazinon, may also be present. As mentioned earlier, the acute toxicity of diazinon has been shown to be additive to chlorpyrifos toxicity.

Risk Quotients Exceed LOCs for Non-target Organisms

Chlorpyrifos is used extensively as an insecticide on most U.S. crops and also has many non-crop uses, which have not been studied or monitored for non-target wildlife effects. Risk quotients have been determined for most agricultural uses and some non-crop uses such as perimeter treatments for termites and golf courses. EECs have not been calculated for some uses, such as nursery uses that are sprayed until runoff and eartags on cattle. Risk quotients have been estimated based on maximum use rates and maximum seasonal poundage permitted by the label. For multiple applications, chlorpyrifos residues are additive using minimum retreatment intervals

(7 days, if not specified on the product label) and appropriate half-lives for soils, foliage and water. Risk quotients have also been calculated for typical use rates identified by BEAD for select major crop uses.

Risk quotients indicate that a single application of chlorpyrifos poses high risks to small mammals, birds, fish and aquatic invertebrate species for nearly all registered outdoor uses. Multiple applications increase the risks to wildlife and prolong exposures to toxic concentrations. In most cases, acute risk quotients exceed 1 for the most sensitive, small mammals and birds. All aquatic acute and reproductive risk quotients (using GENEEC and/or PRZM/EXAMS EECs for the edge of the field ponds) exceed 1 and frequently some aquatic risk quotients exceed 10 and 100. In the case of the maximum use rate on tobacco, both acute and reproductive risk quotients for estuarine invertebrates exceed 1,000. In a few cases at maximum application rates, chlorpyrifos may bioconcentrate in the tissues of fish and aquatic invertebrates to levels that result in bioaccumulations which exceed acute $LC_{50}$ values for sensitive bird species and reproductive NOELs for birds and small mammalian species. Hence bioconcentration of chlorpyrifos in ponds and estuarine areas may pose acute and/or reproductive risks to aquatic birds and mammals feeding adjacent to treated areas. The assessment that wildlife are at risk is support by the occurrence of deaths and adverse effects on wildlife reported in the three field studies for both spray and granular applications of chlorpyrifos.

### c. Risks to Specific Groups of Nontarget Organisms

#### (i) Risks to Terrestrial Mammals

Risk quotients for both maximum and typical use rates exceed the levels of concern for small mammalian herbivores and insectivores for most crop and non-crop uses of chlorpyrifos. The high risk LOC (0.5) for the mammalian acute oral $LD_{50}$ values is usually exceeded for 15 gram mammals, frequently exceeded for 35 gram mammals and occasionally exceeded for 1000 gram mammals. The high risk LOC (0.5) for mammalian subacute dietary $LC_{50}$ is rarely exceeded, but the restricted use LOC (0.2) is exceeded frequently. The LOC for reproductive effects (1.0) is usually exceeded. Deaths of several small mammal and behavior consistent with cholinesterase inhibition in field studies are indicated by positive chemical analyses made for chlorpyrifos residues in carcasses as a result of both spray and granular chlorpyrifos applications.

#### (ii) Risks to Terrestrial Birds and Reptiles

Risk quotients for both maximum and typical application rates for spray uses usually exceed the levels of concern for high risks (0.5) for subacute $LC_{50}$s and (1.0) for reproduction NOEL for avian species. Risk quotients for both maximum and typical application rates for granular uses usually exceed the level of concern for high risks (0.5) for acute oral $LD_{50}$s. Results from the three terrestrial field studies on corn, citrus and golf courses and several incidents with robins and other bird species reported for lawn and residential perimeter treatments associated with termiticide uses, support risk quotient assessments of risks to both birds and reptiles from

chlorpyrifos uses.

Chlorpyrifos-treated fields are unlikely to produce the large visible bird kills, like those reported for carbofuran and some other fast-acting insecticides, which is not to say that many birds are not killed by chlorpyrifos. In the chlorpyrifos acute oral tests, the onset of avian symptoms predominately occurred between 20 minutes and 4 hours after dosing and deaths occurred within 24 hours. Thus, birds have adequate time to feed in chlorpyrifos-treated fields, leave the treated area and disperse to other habitats before they begin to experience toxic symptoms, then they seek refuge and hide before dying. The probability of finding dead wildlife is strongly reduced based on the average carcass recovery rate in habitats adjacent to corn (i.e., 5.8 percent recovery) and reported predation and removal rates of carcasses in the golf course study (i.e., 50 percent in 2 days and 99 percent in 4 days). The only way to determine the extent of avian deaths for chlorpyrifos under field conditions is to monitor mortality in field studies using radiotelemetry to determine the fate of each bird.

Sensitivity of reptiles to pesticides is assumed to be similar or less sensitive than birds, hence the avian risk quotients apply to reptiles as well. Some snake carcasses tested positive for chlorpyrifos in two of the three field studies. The presence of chlorpyrifos in snake carcasses suggests secondary toxicity (i.e., death caused by a chemical present in the carcass of an animal eaten by the predator). The likelihood of secondary toxicity of chlorpyrifos increases the potential of risks to numerous carrion-eating animals from chlorpyrifos use. Carrion feeders would include such animals as owls, peregrine falcon, golden eagle, bald eagle, crows, ravens, vultures, condors, coyotes, foxes, raccoons, skunks, and some snakes.

### (iii) Risks to Bees and Beneficial Insects

Chlorpyrifos is highly acutely toxic to honey bees and applications would be expected to pose a risk to bees and beneficial insects present in the treated area during application. At present, there is no accepted method to determine risk quotients based on the bee acute contact toxicity data. Results from some field studies confirm predicted risks to bees, which are killed if present during application and for as long as 24 hours after treatment.

### (iv) Risks to Earthworms

Chlorpyrifos applications may pose a slight risk to earthworm populations. Field studies indicate consistent reductions in the number of earthworms and earthworm biomass following an application of 2 lb ai/A of an 2 EC formulation. The results in these studies were reported as statistically insignificant ($P < 0.05$). Higher application rates than 2 lbs a.i./acre listed on labels may yield greater effects on earthworm populations than indicated by the results of this study.

### (v) Risks to Fish and Amphibians

Risk quotients exceed the levels of concern for high acute toxicity (0.5) and chronic effects (1.0)

for freshwater and estuarine fish for all uses. Comparison of peak EECs for 14 major crop uses presented in a table in the Surface Water Assessment section to the aquatic acute toxicity values indicates that the six out of fourteen peak EECs exceed the $LC_{50}$ values for the four most sensitive freshwater fish species. Risks to some amphibian tadpoles are assumed to be greater than for the most sensitive fish species, since they are equally sensitive to chlorpyrifos and live in shallower waters.

Reproductive risks to fish populations are indicated by risk quotients which are greater than 21-day EECs for all uses. Fish reproductive effects are likely to be greater than indicated by RQ values presented in risk quotient tables for all chlorpyrifos uses. The fathead minnow tested in the full life-cycle study is approximately 100X less sensitive acutely than other fish species, such as bluegill and trout. Using an acute-to-chronic ratio to estimate a bluegill reproductive NOEC, the ratio yields an estimated NOEC value of 0.005 ppb for bluegill. Since the fathead minnow NOEC was used in the risk tables, the risk quotients for more sensitive fish species would be expected to be greater then estimated in the risk tables. The risk quotients for fish reproductive NOEC might be as much as 100-fold times greater than the value cited in the risk tables.

Fish kills associated with chlorpyrifos terrestrial field studies on citrus and golf courses and some incident reports, usually associated with termiticide treatments of residential buildings, support conclusions of adverse effects on fish as suggested by risk quotients. Also chlorpyrifos levels monitored in some water samples collected from aquatic habitats adjacent to chlorpyrifos-treated corn, citrus, and golf courses exceed their respective EECs used to estimate the fish risk quotients. In fact, at least one water sample per study had measured chlorpyrifos levels equal to or exceeding the bluegill $LC_{50}$ value. Another assessment can be made by comparing chlorpyrifos levels in the microcosm, mesocosm, and aquatic field studies to control mosquito larvae and other aquatic pests where adverse effects have been found, to EECs used to determine the fish risk quotients (see additional information on effects under the section on Field Monitoring Studies below).

### (vi) Risks to Aquatic Invertebrates

Risk quotients for all uses exceed the levels of concern for high toxicity (0.5) for acute toxicity and chronic toxicity (1.0) for freshwater and estuarine invertebrates for outdoor uses assessed in this document. Risk quotients for estuarine invertebrate reproduction are likely to underestimate the risks, because a NOEC was not obtained in the mysid life-cycle study. Comparison of peak EECs for 14 major crop uses presented in a table in the Surface Water Assessment section to $EC_{50}/LC_{50}$ values for the four freshwater invertebrates indicates that the eight out of fourteen peak EECs exceed the $EC_{50}/LC_{50}$ values for three out of the four freshwater species. The acute and reproductive risks to the sensitive aquatic invertebrate species are expected to last for a long term. Predictions of long term effects are consistent with population effects on some invertebrate species observed in aquatic field studies. No aquatic invertebrate observations were made following applications of chlorpyrifos to terrestrial, crops or non-crop uses. The estuarine mysid shrimp is even more sensitive to chlorpyrifos than freshwater invertebrate species.

Reports of aquatic invertebrate kills are relatively rarely observed, probably because invertebrates do not have swim bladders and do not float to the surface like many fish species. Aquatic invertebrates are also less likely to be found because they are small, usually colored to hide in their habitat, and are quickly eaten by predators. Although no dead aquatic invertebrates were reported in the fish kills associated with chlorpyrifos terrestrial field studies on citrus and golf courses, chlorpyrifos levels monitored in some water samples collected from aquatic habitats adjacent to chlorpyrifos-treated corn, citrus, and golf courses, exceed their respective EECs and equal or exceed the acute $EC_{50}$ values for many invertbrate species. Another assessment can be made by comparing chlorpyrifos levels in the microcosm, mesocosm, and aquatic field studies to control mosquito larvae and other aquatic pests where adverse effects have been found, to EECs used to determine the fish risk quotients (see additional details in the section below).

**(vii) Risks to Freshwater Organisms in Field Monitoring Studies**

Chlorpyrifos levels were measured in aquatic areas adjacent to treated fields in three field studies. In the Iowa corn field study, mean measured, chlorpyrifos residue levels in water samples ranged from non-detect to 66.9 ppb and as high as 115 ppb adjacent to spray treated fields. The measured 66.9 ppb level exceeds all predicted EECs which range from 6.8 to 24 ppb. In the granular-treated corn field study, only one water sample had measurable chlorpyrifos levels (1.80 ppb) which was sampled seven days after the tassel broadcast treatment. The measured 1.80 ppm concentration is less than predicted EECs that ranged from 5.5 to 8.6 ppb. In the California citrus field study, some measured chlorpyrifos residue levels in water samples also exceeded predicted EECs (i.e., mean measured levels ranged from non-detected to 244 ppb versus predicted EECs which range from 7.6 to 29.7 ppb). Measured chlorpyrifos up to 2.55 ppb were found in water samples taken from aquatic areas adjacent to granular-treated turf in the central Florida golf course field study.

In the California citrus field study, dead fish and other aquatic vertebrates were found in ponds adjacent to treated groves on several occasions. Dead fish were also found in ponds adjacent to treated golf courses in a central Florida field study. While there were no reported fill kills reported in the corn field study, chlorpyrifos was measured in water samples collected adjacent to 4 out of 8 chlorpyrifos-treated fields. Measured chlorpyrifos in water adjacent to treated corn fields were as high as 115 ppb (almost 100 times the bluegill $LC_{50}$ value and 1,000 times the aquatic invertebrate $EC_{50}$ value).

Monitoring studies have found chlorpyrifos residues in fish nationwide and in water regionally. Results from a national fish monitoring study by the Office of Science and Technology indicates that 20 percent of the fish nationwide had measurable levels of chlorpyrifos residues (EPA 1992). The NOAA (1992) document on Agricultural Pesticide Use in Coastal Areas: A National Summary reports 2.3 - 59 ppb chlorpyrifos in mussels in coastal California, 245 ppb in sediments in Buzzards Bay, MA. Storet reports measurable chlorpyrifos levels in biota in 12 states and in one water sample. These monitoring results indicate widespread and persistent occurrence of chlorpyrifos in aquatic areas throughout the nation. While these results should raise concerns, it is

uncertain whether the chlorpyrifos levels in aquatic organism tissues are sufficient to adversely affect exposed organisms. Risks to benthic organisms exposed to chlorpyrifos sorbed to soils and sediments ($K_{oc}$ 6070) have not been assessed. Currently, requirement of sediment toxicity tests are infrequent and sediment toxicity studies have not been voluntarily submitted.

In a California Control Board Memorandum from Val Connor (dated Dec. 13, 1996, unpublished), chlorpyrifos was reported to exceed the California Department of Fish and Game water quality criterion of 15 ng/L (pptr) in monitoring data from 1994 to 1995 for urban storm runoff episodes collected in receiving waters in the San Francisco Bay area. Out of ninety receiving water samples collected from Sacramento and Stockton, approximately 80 percent of these samples exceeded the California water quality criteria. In the San Francisco Bay area, approximately 75 percent of the 46 samples collected exceeded the water quality criterion. Rainfall samples also collected in the San Francisco area contained chlorpyrifos at levels toxic to *Ceriodaphnia*. In another California monitoring study (California Central Valley Regional Water Quality Control Board, dated Dec. 1995, unpublished), chlorpyrifos residues exceeded water quality criterion about half the time in agricultural areas along a 43-mile reach of the San Joaquin River between the confluence of the Merced and Stanislaus Rivers during 1988-90. During the 1991-92 monitoring period, 45 percent of the water samples collected from the Turlock Irrigation District Lateral (canal) Number 5 (TID5) on the east side of the valley contained chlorpyrifos which tested toxic to *Ceriodaphnia*. On the west side of the valley, 22 percent of the water samples from Orestimba Creek had chlorpyifos levels which tested toxic to *Ceriodaphnia*. In this study, chlorpyrifos was found more frequently in water samples than any other pesticide (i.e., detected 85 times and 18 samples had concentrations which are toxic to *Ceriodaphnia*). Diazinon was second most frequently found pesticide measured 81 times with 4 toxic samples. Almost half of all water samples analyzed during the 1991-92 study for pesticides (toxic and non-toxic) contained both chemicals and the toxicity of the two are additive (Huang *et al*. 1994).

### (viii) Risks to Piscivorous Birds and Mammals from Bioconcentration of Chlorpyrifos in the Food Chain

For high application uses, chlorpyrifos levels in fish and aquatic invertebrates are estimated to exceed the avian subacute dietary toxicity value (136 ppm) and reproductive NOELs for birds (25 ppm) and mammals (10 ppm) for some uses.

Levels of chlorpyrifos in fish and aquatic invertebrates may be underestimated, because residues were calculated for uptake only from water and do not include dietary or sediment exposures. Prey species would also be expected to bioaccumulate chlorpyrifos and pose an alternative exposure to predators.

### (ix) Risks to Nontarget Plants

Risks to non-target terrestrial plants can not be assessed for chlorpyrifos, because toxicity studies are not required for insecticides. The Science Advisory Panel has recently approved testing

requirements for non-target plants for insecticides. These tests will be required when 40 CFR Part 158 is revised and published.

Toxicity data are available for only one out of five recommended aquatic plant species. Based on toxicity values for three estuarine algal species (only one recommended species), risk quotients for the highest exposures do not exceed any level of concern. However, the $EC_{50}$ for all three algal species were exceeded by measured chlorpyrifos levels in some water samples found in the citrus field study. Assessment of risks to other aquatic plant species is deferred until those studies are submitted. Testing of aquatic plants will also be required for insecticides, when 40 CFR Part 158 is revised and published.

#### (x) Risk Characterization of Chlorpyrifos' Major Degradate

EFED has identified a number of degradates/metabolites for chlorpyrifos. The major degradate was identified as 3,5,6-trichloro-2-pyridinol. A full set of acute studies have been submitted. The acute toxicity values indicate that the major degradate range from moderately toxic to practically non-toxic. Degradate toxicity values are as follows: $LD_{50}$ for bobwhite > 2,000 mg/kg; mallard $LC_{50}$ > 3,316 ppm; bluegill 12.5 ppm; rainbow trout 12.6 ppm; daphnids 10.4 ppm; Atlantic silverside $LC_{50}$ 58.4 ppm; grass shrimp $LC_{50}$ 83 ppm; and eastern oyster shell deposition $LC_{50}$ 9.3 ppm. In all cases, the major degradate is less acutely toxic than chlorpyrifos, hence risks to fish and wildlife would appear to be reduced as chlorpyrifos degrades.

### d. Select Toxicity Values for Risk Assessment

#### (i) Toxicity Values and Toxicity Conversions

The acute toxicity of chlorpyrifos is well characterized for a wide variety of wildlife species. Reproduction studies are available for the normal array of terrestrial and aquatic species. The following toxicity values were selected as the most sensitive endpoints for each test type.

#### (a) Mammalian Toxicity Values and Conversions

The lowest mammalian acute $LD_{50}$ value is 97 mg/kg for rats (0.40 kg body weight). One-day $LC_{50}$ values were calculated for small to medium-sized mammals of various sizes and dietary preferences (see table below). The lowest subacute 5-day dietary $LC_{50}$ value is 1330 ppm for rats. A NOEL from a two-generation rat reproduction study is 1 mg/kg/day (10 ppm for the young). Reduced pup body weight and increased mortality in young are the most sensitive mammalian reproductive endpoints.

Assessment of risks to small mammals using the residues on food items requires that the acute oral $LD_{50}$ values be converted to estimate $LC_{50}$ values for dietary exposure. $LC_{50}$ values were estimated for a variety of small to medium-sized mammals having different dietary needs using the following formula:

$$\text{1-day } LC_{50}(\text{mg/kg/day}) = \frac{LD_{50}\text{ (mg/kg) x body wt.(kg) x 100\%}}{\text{\% body wt. eaten/day x body wt.(kg)}}$$

| Mammalian Species | Body Weight (g) | % Body Wt Consumed per day | Rat LD50 mg/kg | Est. 1-day LC50 ppm |
|---|---|---|---|---|
| Herbivores/Insectivores | 15<br>35<br>1000 | 95<br>66<br>15 | 97 | 102<br>147<br>647 |
| Granivores | 15<br>35<br>1000 | 21<br>15<br>3 | 97 | 462<br>647<br>3233 |

In order to assess risk, these estimated mammalian 1-day $LC_{50}$ values are divided into the appropriate residues for the respective food type to calculate a risk quotient (i.e., $EEC/LC_{50}$). Each risk assessment table provides exposures and the toxicity values for various surrogate species used to calculate the risk quotients for wildlife groups for the crop(s), application rate, and use methods specified in the table heading. In determining dietary risks to terrestrial species, a range of dietary exposures are assessed to cover a range of items in the diet. For example, a herbivore may feed on foliage at 135 ppm per 1 lb ai/A and short grass at 240 ppm per 1 lb ai/A. The extent to which a species prefers one or the other food item, and actually feeds on treated food, will determine risk.

### (b) Avian Toxicity Values

The following toxicity values were selected as the most sensitive avian endpoints. The avian acute $LD_{50}$ value used is 10 mg/kg for the house sparrow (times O.0277 kg body weight) which is equivalent to a $LD_{50}$ dose of 0.277 mg versus 0.641 mg for the common grackle ($LD_{50}$ 5.62 mg/kg X 0.114 kg). The lowest avian subacute dietary $LC_{50}$ value is 136 ppm for mallard ducks. The mallard duck is the most sensitive avian species tested with a reproductive NOEL of 25 ppm based on significant 84% reduction in the number of eggs laid; 40% and 16% reductions in drake and hen survival, respectively; 9% reduction in eggshell thickness; and 89% fewer young.

### (c) Freshwater and Estuarine Toxicity Values

The following toxicity values were selected as the most sensitive aquatic endpoints for freshwater and estuarine species of fish and invertebrates. These aquatic toxicity values used are an acute $LC_{50}$ value of 1.8 ppb for bluegills; a NOEC of 0.57 ppb for fathead minnow reproduction (14% reduction in $F_0$ survival and 35% reduction in $F_1$ survival at 1.09 ppb); an acute $LC_{50}$ value of 0.10 ppb for daphnids and a NOEC of 0.04 ppb for daphnid reproduction (100% reductions in adult survival and number of offspring).

The estuarine/marine toxicity values identified as the most sensitive endpoints are an acute $LC_{50}$ of 0.96 ppb for silversides, a fish; a NOEC of 0.28 ppb for silverside reproduction (74% reduction in young survival); an acute $LC_{50}$ of 0.035 ppb for mysid shrimp; and a NOEC of less than 0.0046

ppb mysid reproduction (85% reduction in the number of young).

### (d) Piscivore Toxicity Values and Bioconcentration Factors (BCF) Values

The toxicity values for determining risk from exposures resulting from bioconcentration are the same subacute and chronic toxicity values used in the terrestrial risk assessment. Laboratory studies show that chlorpyrifos bioconcentrates in fish with BCF values of 2730X for whole fish, 3900X for fish viscera, and 1280X for fish edible tissues (i.e., fish fillet). An oyster study yielded BCF values of 2500X in oyster tissue, 1900 in whole oyster, and 87X in oyster liquor. Since predatory mammals and birds usually eat the soft viscera prior to eating the muscle or eat its prey whole, the exposure levels in fish and aquatic invertebrates used to assess risks are calculated using the fish viscera and whole fish BCF values.

### (e) Plant Toxicity Values

Toxicity studies were unavailable for chlorpyrifos to terrestrial plants. Recently, a requirement for short-term toxicity studies on 10 terrestrial plant species, 5 algal species, and 1 aquatic vascular plant species has been approved. Toxicity data are available on only two aquatic plant species. The most sensitive algal $EC_{50}$ value is 140 ppb.

## e. Ecological Exposures and Risk Characterization

Chlorpyrifos is registered for spray and granular applications on many crops and has many non-crop uses. Wildlife risks are assessed for maximum registered chlorpyrifos use rates for crops and such non-crop applications as lawn care and other outdoor pest control uses. Maximum use rates on crops range from 0.5 to 6 lbs ai/A for a single application. Multiple applications are registered on many crops with up to 22 applications on sweet corn in some states. Wildlife risks also are assessed for typical use rates identified by the Biological and Economic Analysis Division (BEAD) for major crop uses.

### (i) Risk Assessments for Corn

The risk assessment for chlorpyrifos use on corn is addressed separately from other crops, because chlorpyrifos use on corn represents about 55 percent of the total chlorpyrifos poundage used on U.S. crops. Also, corn applications are diverse and pose some unique routes of exposure to terrestrial wildlife.

Chlorpyrifos can be applied to corn seed and corn at all stages of growth. Four chlorpyrifos formulations are applied to field corn, sweet corn, popcorn, or corn grown for seed. These formulations are Lorsban 4 EC and three granular formulations (0.5% G, 1% G and 15% G). Chlorpyrifos formulations used on corn are Lorsban 15 G which is the primarily used for pre-plant and at-plant applications and Lorsban 4 EC. The 0.5% G and 1% G formulations are for

homeowner use. Chlorpyrifos is applied to about 7 percent (8% is the likely maximum) of the approximate 71,260,000 acres of corn in the US.

Chlorpyrifos uses on corn include applications: to stored and preplant seeds (slurry treatments with 50% WP only); preplant with soil incorporation (4 EC and 15 G); at plant, in band treatments (4 EC and all four granular formulations) and in-furrow (15 G); preemergence broadcast (4 EC); at cultivation side-dress (4 EC and 15 G); and postemergence broadcast (4 EC and 15 G). Chlorpyrifos use pattern data were obtained from the use information used by HED for crops and provided by Dow for non-food uses. Application rates on corn, number of applications, and minimal time interval between treatments are summarized below in a table for each formulation, in order to easily compare risks for each growth stage for different use rates and formulations.

| Application Type and Application Method | Chlorpyrifos Formulation | Application Rates (expressed as ai) | Maximum Number of Applications | Maximum lb ai/A per Season | Treatment Interval (days) |
|---|---|---|---|---|---|
| Seed Treatments: | | | | | |
| Stored Seeds: | 50 % WP | 1 oz. ai./100 lbs. of seed | 1 | NA | NA |
| Preplant Seed: | | 1 oz. ai./100 lbs. of seed | 1 | NA | NA |
| Pre-plant: | 4 EC | 1 lb/A in ≥ 10 gal./A | 1 | NA | NA |
| Broadcast | (2-4") | 2 lb/A in ≥ 10 gal./A | 1 | NA | NA |
| | | 3 lb/A in ≥ 10 gal./A | 1 | NA | NA |
| (Soil Depth of | 15 G | 1 lb/A | 1 | NA | NA |
| Incorporation) | (4-6") | 2 lb/A | 1 | NA | NA |
| At Plant: | 4 EC | 1 lb/A in ≥ 20 gal. | 1 | NA | NA |
| Broadcast | | 2 lb/A in ≥ 20 gal. | 1 | NA | NA |
| At Plant: | 0.5 G | 2.4 oz/ 1,000 ft. | 1 | NA | NA |
| Soil Band | 1 G | 2.4 oz/ 1,000 ft. | 1 | NA | NA |
| Soil incorporated | 15 G | 1.2 oz/ 1,000 ft. | 1 | NA | NA |
| 0.5 to 2" deep | (6-7" wide) | 1.8 oz/ 1,000 ft. | 1 | NA | NA |
| (15% available) | (6-7" wide) | 2.4 oz/ 1,000 ft. | 1 | NA | NA |
| | (7-10" wide) | 2.4 oz/ 1,000 ft. | 1 | NA | NA |
| At Plant: | 15 G | 1.2 oz/ 1,000 ft. | 1 | NA | NA |
| In-furrow | (assume | 1.8 oz/ 1,000 ft. | 1 | NA | NA |
| (1% available) | 6" wide) | | | | |
| Preemergence: | 4 EC | 0.25 lb/A in ≥ 20 gal. | 1 | NA | NA |
| Broadcast | | 0.5 lb/A in ≥ 20 gal. | 1 | NA | Na |
| Cultivation: | 4 EC | 1 lb/A | 1 | NA | NA |
| Sidedress | 15 G | 0.9 oz/ 1,000 ft. | 1 | NA | NA |
| | | 1.2 oz/ 1,000 ft. | 1 | NA | NA |
| Postemergence: | 4 EC | 0.25 lb/A in 20-40 gal. | 1 | 7.5 lb/A | as needed |
| Broadcast | | | 2 | | (assume 7) |
| (ground spray | | 0.5 lb/A in 20-40 gal. | 1 | 7.5 lb/A | as needed |
| in 20-40 gal.) | | | 2 | | (assume 7) |
| or | | 1 lb/A in 20-40 gal. | 1 | 7.5 lb/A | as needed |
| (aerial spray | | | 2 | | (assume 7) |
| in sufficient water) | | 1.25 lb/A in 20-40 gal. | 1 | 7.5 lb/A | as needed |
| | | | 2 | | (assume 7) |
| | | 1.5 lb/A in 20-40 gal. | 1 | 7.5 lb/A | as needed |
| | | | 2 | | (assume 7) |
| (ground & aerial) | 15 G | 0.75 lb/A | 1 | 2.025 lb/A | as needed |
| | | | 2 | | (assume 7) |
| | | 0.975 lb/A | 1 | 2.025 lb/A | |
| | | | 2 | | |

| | | | | | |
|---|---|---|---|---|---|
| Sweet Corn:<br>(FL & GA only)<br>Broadcast | 4 EC<br>(aerial 2 gal.)<br><br>4 EC<br>(ground) | 0.5 lb/A<br><br>1 lb/A<br>0.5 lb/A<br>1 lb/A | 22<br><br>11<br>22<br>11 | 11 lb/A<br><br>11 lb/A<br>11 lb/A<br>11 lb/A | as needed<br>(assume 3)<br>"<br>"<br>" |

**Seed Treatments (Stored and at Plant)**:

Seed treatment of corn with chlorpyrifos may result in several routes of exposure leading to risk concerns for wildlife. Birds and small mammals may feed on treated corn kernels in storage, treated corn kernels left exposed on top of the soil after planting, or remaining residues in young corn sprouts. Corn seed may be consumed by birds and small mammals in single feedings resulting in acute effects or as continuous dietary exposures for short or long periods. Treated corn kept in storage areas may be available to birds and small mammals, such as sparrows, mice, rats, etc., which enter storage areas. While toxic effects on these species are assessed here, death of these species may be of little or no concern to society, because grain losses due to wildlife may require pest control efforts to prevent loss.

**Stored Seed Treatment for Corn Uses**: Stored corn seed may be treated with chlorpyrifos (50% WP) at 0.038 - 0.076 oz. (0.019-0.038 oz. a.i.) per 100 lbs of seed, as an aqueous solution of 12 to 24 ppm (6 to 12 ppm a.i.). The following stored seeds may be treated at the same rates: field beans, green beans, kidney beans, lima beans, navy beans, snap beans, string beans, wax beans, field corn, sweet corn, cucumbers, black-eyed peas, field peas, garden peas, and pumpkins. The 24 ppm rate will provide a longer period of protection. The formulae used to calculate exposures and risk quotients for treated seeds are listed below. Chlorpyrifos application rate and risk quotients (RQ) are summarized in the following table.

$$LD_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X (LD50 X kg body wt.)}}$$

$$LC_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X 0.4535 kg/lb X (LC50 or NOEL)}}$$

| Application Type and Application Method | Chlorpyrifos Formulation | Application Rates (expressed as ai) | Maximum Number of Applications | Maximum lb ai/A per Season | Treatment Interval (days) | Risk Quotients<br>Bird Acute / Chronic | Risk Quotients<br>Mammal Acute / Chronic |
|---|---|---|---|---|---|---|---|
| Stored Seed Treatment | 50 % WP | 0.038 oz/100 lb | 1 | NA | NA | Acute Oral LD50s<br>39 / -- | <br>0.56 / -- |
| | | | | | | Dietary $LC_{50}$s and Chronic NOECs<br>0.17 / 25 | <br>0.02 / 2.4 |

**Risk quotients for Stored Seed Treatment**: Risks to wildlife consuming stored seed corn treated with chlorpyrifos are high to birds for acute and chronic exposures and high to small mammals for acute and chronic exposures. Levels of concern are exceeded by treated stored seeds, but concern for likely consumers: mice, rats and pigeons is low because these pests would likely have to be baited to control, if the seed were not toxic to these pests.

**Treated Seed at Planting Uses**: During planting, chlorpyrifos-treated corn kernels and other seeds may be accidently scattered on the soil surface, especially when the planter is withdrawn from the soil at the end of a row. Since the kernels are planted in-furrow, it is assumed that only 1 percent of the kernels are exposed during planting, which assumes the same percentage as for the exposed granules when placed in-furrow. Chlorpyrifos 50 WP (50 % a.i.) is applied to preplant seed corn and other seeds at 2 oz. (1 oz. a.i.) per 100 lbs of seed (2 oz. a.i. for cotton seed). It is assumed that the corn planting rates are 18 to 20 lbs/A for field corn, 8 to 16 lbs/A for sweet corn, and 3 to 6 lbs/A for popcorn. The formulae presented below give risk quotients for acute effects from consuming treated corn seed; acute exposure to exposed kernels in the field per square foot; and subacute dietary and reproductive effects from exposed kernels. The risks are assessed in the following table.

$$LD_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X (LD50 X kg body wt.)}}$$

$$LC_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X 0.4535 kg/lb X (LC50 or NOEL)}}$$

| Application Type and Application Method | Chlorpyrifos Formulation | Application Rates (expressed as ai) | Maximum Number of Applications | Maximum lb ai/A per Season | Treatment Interval (days) | Risk Quotients<br>Bird Acute / Chronic | Mammal Acute / Chronic |
|---|---|---|---|---|---|---|---|
| Preplant Seed Treatment | 50 % WP | 1 oz./100 lb | 1 | NA | NA | Acute Oral LD50s<br>1020 / -- | 14 / -- |
| | | | | | | Dietary $LC_{50}$s and Chronic NOECs<br>4.6 / 25 | 0.47 / 62 |

An alternative method to assessing risks as risk quotients is to estimate the number of chlorpyrifos-treated corn kernels equivalent to the acute oral $LD_{50}$. The formula to calculate the number of seeds per mg of chlorpyrifos is presented below. And the following table indicates the number of corn kernels equivalent to the acute oral $LD_{50}$ for some select wildlife species.

$$\text{mg ai/corn kernel} = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{3 corn kernels/g X 1000 g/kg X 100 lb X 0.4535 kg/lb}}$$

**At-plant Risks to Wildlife Expressed as RQs per Kernel and Number of Kernels per $LD_{50}$**
(Assumes 0.2 mg ai per corn kernel when treated at 1 oz. ai/ 100 lbs of corn seed)

| **Species** | **$LD_{50}$ (mg/kg body wt.)** | **Body Weight (kg)** | **RQ / Kernel** | **Kernels / $LD_{50}$** |
|---|---|---|---|---|
| House Sparrow *Passer domesticus* | 10 | 0.0277 | 0.72 | 1.4 |
| Common Grackle *Quiscalus quiscula* | 5.62 | 0.114 | 0.31 | 3.2 |
| Red-winged Blackbird *Agelaius phoeniceus* | 13.1 | 0.0526 | 0.29 | 3.4 |
| Mammal (15 grams body wt.) | 97 | 0.015 | 0.14 | 7.3 |

| | | | | |
|---|---|---|---|---|
| Japanese Quail<br>*Coturnix japonica* | 13.3 | 0.178 | 0.084 | 12 |
| Rock Dove<br>*Columbia livia* | 26.9 | 0.100 | 0.074 | 13 |
| Mammal (35 grams body wt.) | 97 | 0.035 | 0.059 | 17 |
| Common Pigeon<br>*Columba livia* | 10 | 0.040 | 0.050 | 20 |
| Bobwhite Quail<br>*Colinus virginianus* | 32 | 0.178 | 0.035 | 28 |
| Starling<br>*Sturnus vulgaris* | 75 | 0.0823 | 0.032 | 31 |
| Ring-necked Pheasant<br>*Phasianus colchicus* | 8.41 | 1.135 | 0.021 | 48 |
| Rat<br>*Rattus norvegicus* | 97 | 0.200 | 0.010 | 97 |
| Cockerel<br>*Gallus domesticus* | 34.8 | 1.500 | 0.0038 | 261 |
| Mallard Duck<br>*Anas platyrhynchos* | 75.6 | 1.082 | 0.0024 | 409 |
| Mammal (1000 grams body wt.) | 97 | 1.000 | 0.0021 | 485 |

**Risk Summary for Preplant Seed Treatment for Corn**: Preplant treatment of seed corn with Lorsban 50 WP may pose high risks to birds and small mammals. Each corn kernel contains an average of 0.20 mg chlorpyrifos. If treated kernels are consumed by wildlife, the acute risk quotients from a single kernel is a high risk (LOC $\geq$ 0.5) to house sparrows (RQ = 0.72) and a moderate-to-low risk to small mammals (RQ = 0.14). The LOC (0.1) for endangered species is exceeded for four species eating a single corn kernnel. Some avian species, such as crows, which pull up and eat young corn sprouts, are also exposed to chlorpyrifos in the sprout. However, chlorpyrifos concentrations in the sprout will be reduced to an unknown degree as a result of leaching and/or degradation. Hence, risks to species feeding on young sprouts will be less than if they feed on the corn kernels.

The number of treated kernels which are equivalent to LD50 values were calculated for several wildlife species for which there are LD50 values. The number of treated corn kernels with chlorpyrifos levels equivalent to LD50 doses are 1.4 kernels for house sparrows, 3.2 for common grackles, 3.3 for red-winged blackbirds, etc.. It is reasonable to expect that sparrows are liable to eat exposed corn kernels by pecking kernels into smaller pieces and could be at risk. Other species such as the common grackle, red-winged blackbirds, and rock doves could easily consume enough kernels to be killed. For some less sensitive species, such as mallard ducks, it is uncertain whether they could eat enough kernels to be affected. Since the amount of exposed corn kernels necessary to equal the $LD_{50}$s are within about 16 percent of their body weight, it is possible for acute risk quotients for all species to be 1.0 or greater with a bit of gluttony. In summary, treated corn kernels pose a high potential risk to most or all avian species and small mammals.

Use of the $LD_{50}/ft^2$ criteria to assess wildlife risks appears to be inappropriate in the case of treated seeds at planting. If it is assumed that the per square foot area is a 1-inch wide band and 144 inches long and that corn is planted every four inches, only 36 seeds are planted in that 1 sq. ft. area. If it is assumed that an average of only 1 percent of the seeds are exposed as in the case for in-furrow granular applications, the exposure is 0.36 exposed seeds per square foot and the risks would appear low. However, birds are adept at finding seeds over large areas, and it is likely that individual birds will find several seeds spread over a larger area. Since only a few seeds are needed to exceed the $LD_{50}$s of some species, it would appear that the risks to these species may be high. Consequently, it would be inappropriate to assess risks to wildlife on a per square foot basis.

**Corn Uses**: Corn is the major crop use for chlorpyrifos with about 55 percent of the total agriculture poundage. Chlorpyrifos is primarily applied to corn as a granular formulation (i.e., Lorsban 15G) and liquid formulation (i.e., Lorsban 4 EC). Lorsban 30G was registered on November 6, 1998; it unclear whether it has entered commercial use. Homeowner formulations include 0.5% and 1% granular formulations. It is unclear if the Lorsban 7.5 G formulation is still registered.

Chlorpyrifos is applied to corn for a total of about 7 percent (8 percent is likely maximum) of the approximately 71,000,000 acres of corn grown in the U.S. Directions for corn use on registered labels permit chlorpyrifos applications at the following stages: pre-plant, at-plant, postemergence, whorl, and tassel with a maximum seasonal use of 7.5 lbs ai/A. Chlorpyrifos applications may be made by ground, aerial, or sprinkler equipment. Registered labels for special state use allows 11 to 22 treatments at 0.5 to 1.0 lbs ai/A with a maximum seasonal use of 11 lbs ai/A. According to BEAD, the typical application on corn is an at-plant, granular treatment at 1.1 lbs ai/A for soil insects. The leading states using chlorpyrifos on corn in decreasing order of poundage are Illinois, Iowa, Nebraska, Indiana, Wisconsin and Ohio.

Wildlife utilization of corn fields is high with a broad diversity of avian and mammalian species. Wildlife reported to feed moderately to high in corn fields include quail, grouse, partridge, pheasant, prairie chicken, ducks, doves, songbirds (35 species), red fox, muskrat, opossum, raccoon, and deer to a low to high degree. While it is unlikely that deer might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated cotton fields. Bobwhite quail, pheasant (brood-rearing), and rabbits also nest and brood young in corn fields. In the Iowa corn field study, the number of avian species observed in corn field in various replicates ranged from 12 to 24 species in six circular plots per field. The number of individual birds seen in corn replicates ranged from 50 to 110 birds. The number of birds observed in corn fields total 768 birds in the circular plots.

Risk assessments have been made using maximum application rates as an initial screen for effects followed by a refinement with typical usage. Risk quotients have been estimated for spray and granular treatment for all corn growth stages. Risk for uses in Iowa and Mississippi were

assessed and indicate some regional differences in risks. Multiple applications were also assessed for risks from the accumulation of pesticide residues in terrestrial and aquatic systems. Risks for each usage are presented in tables below. Results from an Iowa, corn field study are presented, which, in general, support predicted EECs and adverse effects to birds and small mammals. Although, many dead animals were found, residue analysis was performed on only 9 birds and small mammals. Five animals (56 percent) tested positive for chlorpyrifos residues and one rabbit was found showing signs of cholinesterase inhibition, but it escaped capture.

Corn Preplant Spray Incorporation Use: Directions for corn use on registered labels allow chlorpyrifos (Lorsban 4 EC or 50% WP) to be sprayed by ground equipment at 1, 2 or 3 lbs ai/A mixed in a minimum of 10 gallons of water per acre followed by soil incorporated.

Terrestrial EECs were estimated using the maximum application rate and the residue levels identified by Hoerger and Kenaga (1972) as modified by Fletcher *et al*. (1994). While soil incorporation following spray applications may reduce the amount of treated vegetation, seeds, and insects that are available to wildlife on the surface, it is assumed that soil incorporation does not reduce the pesticide concentrations on the food items. Soil incorporation reduces the amount of pesticide available for runoff.

Aquatic EECs were modelled by EFED using the PRZM3-EXAMS model on Marshall silty clay loam soil in Iowa and local rainfall conditions. Risk quotients for wildlife and aquatic species exposed to the spray-treatment corn are presented in the following tables for easy comparison of wildlife risks for different formulations and different use rates in other tables.

**Risk Quotients for Corn**
**(Pre-plant Ground Spray; 1 Application at 3 lbs ai/A; 2-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Exposure | Toxicity | Risk Quotients |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 405[1] - 720[2] ppm | 102 ppm<br>147 ppm<br>647 ppm | 4.0 - 7.1<br>2.8 - 4.9<br>0.63 - 1.4 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45[3] - 405[4] ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.44 - 4.0<br>0.31 - 2.8<br>0.07 - 0.63 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45[5] ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.097<br>0.070<br>0.014 |
| Mammalian Subacute Dietary $LC_{50}$ | 45 - 720 ppm | 1330 ppm | 0.034- 0.54 |
| Mammalian Reproduction NOEL | 45 - 720 ppm | 10 ppm | 4.5 -72 |
| Avian Subacute Dietary $LC_{50}$ | 45 - 720 ppm | 136 ppm | 0.33 - 5.3 |
| Avian Reproduction NOEL | 45 - 720 ppm | 25 ppm | 1.8 -29 |
| Freshwater Fish Acute $LC_{50}$ | 11.1[6] ppb | 1.8 ppb | 6.2 |

| | | | |
|---|---|---|---|
| Fish Reproduction NOEC | 4.5[7] - 8.7[8] ppb | 0.57 ppb | 7.9 - 15 |
| Aquatic Invertebrate Acute $LC_{50}$ | 11.1 ppb | 0.10 ppb | 110 |
| Freshwater Invert. Reproduction NOEC | 4.5 - 8.7 ppb | 0.04 ppb | 110 - 220 |
| Estuarine Fish Acute $LC_{50}$ | 11.1 ppb | 0.96 ppb | 11.6 |
| Estuarine Fish Reproduction NOEC | 4.5 - 8.7 ppb | 0.28 ppb | 16 - 31 |
| Estuarine Invertebrate Acute $LC_{50}$ | 11.1 ppb | 0.035 ppb | 320 |
| Estuarine Invert. Reproduction NOEC | 4.5 - 8.7 ppb | < 0.0046 ppb | > 980 > 1900 |
| Estuarine Algae $EC_{50}$ | 11.1 ppb | 140 ppb | 0.079 |

[1] Upper residue level on foliage exposed in plowed field (135 ppm per lb ai/A applied)
[2] Upper residue level on short grasses exposed in plowed field (240 ppm per lb ai/A applied)
[3] Upper residue level on large insects (135 ppm per lb ai/A applied)
[4] Upper residue level on small insects (15 ppm per lb ai/A applied)
[5] Upper residue level on seeds and fruit (15 ppm per lb ai/A applied)
[6] Peak EEC in 2-meter deep pond or estuarine water
[7] 21-Day EEC in 2-meter deep pond or estuarine water
[8] 96-Hour EEC in 2-meter deep pond or estuarine water

**Risk Summary for Maximum Preplant Spray to Corn**: Chlorpyrifos ground sprayed pre-plant at 3 lbs ai/A and soil incorporated to 2 inches yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.014-7.1), subacute (0.034-0.54) and reproduction NOEL (4.5-72), avian subacute (0.33-5.3) and reproduction NOEL (1.8-29), freshwater fish acute (6.2) and reproduction NOEL (7.9-15), aquatic invertebrate acute (110) and reproduction NOEL (110-220), estuarine fish acute (11.6) and reproduction (16-31) and estuarine invertebrate acute (320) and reproduction NOEL (> 980 > 1900). The algal risk quotient (0.079) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 43 ppm and whole fish of 30 ppm. These levels in fish are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but are more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Postemergence Corn Spray Uses**: Lorsban 4 EC may be applied in three post- emergence applications of 0.25-1.5 lbs ai/A depending on pest (i.e., at emergence, at whorl and at tassel) with a minimum application interval of 10 to 14 days. Three post-treatment scenarios are presented in the following 3 tables: a ground spray application; an aerial spray; and 3 aerial sprays at 14-day intervals.

| **Risk Quotients for Corn<br>(Postemergence/foliar, Ground Spray; 1 Applications at 1.5 lbs ai/A)<br>(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)** | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |

| | | | |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 203 - 360 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.0 - 3.5<br>1.4 - 2.4<br>0.31 - 0.56 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 23 - 203 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.23 - 2.0<br>0.16 - 1.4<br>0.036- 0.31 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 23 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.050<br>0.036<br>0.007 |
| Mammalian Subacute Dietary $LC_{50}$ | 23 - 360 ppm | 1330 ppm | 0.017- 0.27 |
| Mammalian Reproduction NOEL | 23 - 360 ppm | 10 ppm | 2.3 - 36 |
| Avian Subacute Dietary $LC_{50}$ | 23 - 360 ppm | 136 ppm | 0.17- 2.6 |
| Avian Reproduction NOEL | 23 - 360 ppm | 25 ppm | 0.92- 14 |
| Freshwater Fish Acute $LC_{50}$ | 5.5 ppb | 1.8 ppb | 3.1 |
| Fish Reproduction NOEC | 2.7 - 4.8 ppb | 0.57 ppb | 4.7 - 8.4 |
| Aquatic Invertebrate Acute $LC_{50}$ | 5.5 ppb | 0.10 ppb | 55 |
| Freshwater Invert. Reproduction NOEC | 2.7 - 4.8 ppb | 0.04 ppb | 68 - 120 |
| Estuarine Fish Acute $LC_{50}$ | 5.5 ppb | 0.96 ppb | 5.7 |
| Estuarine Fish Reproduction NOEC | 2.7 - 4.8 ppb | 0.28 ppb | 9.6 - 17 |
| Estuarine Invertebrate Acute $LC_{50}$ | 5.5 ppb | 0.035 ppb | 160 |
| Estuarine Invert. Reproduction NOEC | 2.7 - 4.8 ppb | < 0.0046 ppb | > 590 > 1000 |
| Estuarine Algae $EC_{50}$ | 5.5 ppb | 140 ppb | 0.039 |

**Risk Summary for a Maximum Post-emergent Ground Spray on Corn**: Chlorpyrifos sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.007-3.5), subacute (0.017-0.27) and reproduction NOEL (2.3-36), avian subacute (0.17-2.6) and reproduction NOEL (0.92-14), freshwater fish acute (3.1) and reproduction NOEL (4.7-8.4), aquatic invertebrate acute (55) and reproduction NOEL (680-120), estuarine fish acute (5.7) and reproduction (9.6-17) and estuarine invertebrate acute (160) and reproduction NOEL (> 590 > 1000). The algal risk quotient (0.039) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 11 ppm and whole fish of 7.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but near the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but less than the avian reproductive NOEL of 25 ppm.

**Risk Quotients for Corn**
**(Postemergence/foliar, Aerial Spray; 1 Application at 1.5 lbs ai/A)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 203 - 360 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.0 - 3.5<br>1.4 - 2.4<br>0.31 - 0.56 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 23 - 203 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.23 - 2.0<br>0.16 - 1.4<br>0.036- 0.31 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 23 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.050<br>0.036<br>0.007 |
| Mammalian Subacute Dietary $LC_{50}$ | 23 - 360 ppm | 1330 ppm | 0.017- 0.27 |
| Mammalian Reproduction NOEL | 23 - 360 ppm | 10 ppm | 2.3 - 36 |
| Avian Subacute Dietary $LC_{50}$ | 23 - 360 ppm | 136 ppm | 0.17 - 2.6 |
| Avian Reproduction NOEL | 23 - 360 ppm | 25 ppm | 0.92- 14 |
| Freshwater Fish Acute $LC_{50}$ | 7.7 ppb | 1.8 ppb | 4.3 |
| Fish Reproduction NOEC | 3.8 - 6.8 ppb | 0.57 ppb | 6.7 - 12 |
| Aquatic Invertebrate Acute $LC_{50}$ | 7.7 ppb | 0.10 ppb | 77 |
| Freshwater Invert. Reproduction NOEC | 3.8 - 6.8 ppb | 0.04 ppb | 95 - 170 |
| Estuarine Fish Acute $LC_{50}$ | 7.7 ppb | 0.96 ppb | 8.0 |
| Estuarine Fish Reproduction NOEC | 3.8 - 6.8 ppb | 0.28 ppb | 14 - 24 |
| Estuarine Invertebrate Acute $LC_{50}$ | 7.7 ppb | 0.035 ppb | 220 |
| Estuarine Invert. Reproduction NOEC | 3.8 - 6.8 ppb | < 0.0046 ppb | > 830 > 1500 |
| Estuarine Algae $EC_{50}$ | 7.7 ppb | 140 ppb | 0.055 |

**Risk Summary for a Maximum Post-emergent Aerial Spray on Corn**: Chlorpyrifos aerially sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.007-3.5), subacute (0.017-0.27) and reproduction NOEL (2.3-36), avian subacute (0.17-2.6) and reproduction NOEL (0.92-14), freshwater fish acute (4.3) and reproduction NOEL (6.7-12), aquatic invertebrate acute (77) and reproduction NOEL (95-170), estuarine fish acute (8.0) and reproduction (14-24) and estuarine invertebrate acute (220) and reproduction NOEL (> 830 > 1500). The algal risk quotient (0.055) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 15 ppm and whole fish of 10 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Multiple chlorpyrifos applications on corn are permitted by directions on registered chlorpyrifos

labels. In general, label directions permit three of four applications to all types of corn. The time interval between applications is 10 to 14 days. The maximum seasonal use is 7.5 lbs ai/A in most states. In cases of multiple applications of chlorpyrifos, a half-life of 7 days has been assumed as a conservative, but not, upper limit dissipation rate presented by Racke (1993).

**Risk Quotients for Corn (Emergence, Whorl, & Tassel)**
**(Postemergence/foliar, 3 Aerial Applications at 1.5 lbs ai/A; 14-Day Intervals)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EECs Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 266 - 472 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.6 - 4.6<br>1.8 - 3.2<br>0.41 - 0.73 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 266 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046- 0.41 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065<br>0.046<br>0.009 |
| Mammalian Subacute Dietary $LC_{50}$ | 30 - 472 ppm | 1330 ppm | 0.023- 0.35 |
| Mammalian Reproduction NOEL | 30 - 472 ppm | 10 ppm | 3.0 - 47 |
| Avian Subacute Dietary $LC_{50}$ | 30 - 472 ppm | 136 ppm | 0.22 - 3.5 |
| Avian Reproduction NOEL | 30 - 472 ppm | 25 ppm | 1.2 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 24 ppb | 1.8 ppb | 13 |
| Fish Reproduction NOEC | 11.7 -21.5 ppb | 0.57 ppb | 21 - 38 |
| Aquatic Invertebrate Acute $LC_{50}$ | 24 ppb | 0.10 ppb | 240 |
| Freshwater Invert. Reproduction NOEC | 11.7 -21.5 ppb | 0.04 ppb | 290 - 540 |
| Estuarine Fish Acute $LC_{50}$ | 24 ppb | 0.96 ppb | 25 |
| Estuarine Fish Reproduction NOEC | 11.7 -21.5 ppb | 0.28 ppb | 42 - 77 |
| Estuarine Invertebrate Acute $LC_{50}$ | 24 ppb | 0.035 ppb | 690 |
| Estuarine Invert. Reproduction NOEC | 11.7 -21.5 ppb | < 0.0046 ppb | >2500 > 4700 |
| Estuarine Algae $EC_{50}$ | 24 ppb | 140 ppb | 0.17 |

**Risk Summary for Three Maximum, Post-emergent Aerial Spray Treatments on Corn**: Chlorpyrifos aerially sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.009-4.6), subacute (0.023-0.35) and reproduction NOEL (3.0-47), avian subacute (0.22-3.5) and reproduction NOEL (1.2-19), freshwater fish acute (13) and reproduction NOEL (21-38), aquatic invertebrate acute (240) and reproduction NOEL (290-540), estuarine fish acute (25) and reproduction (42-77) and estuarine invertebrate acute (690) and reproduction NOEL (> 2500 > 4700). The algal risk quotient (0.17) does not exceed any

level of concern.

Food Chain Effect: Piscivorous mammals are exposed to estimated residues in the fish viscera of 46 ppm and whole fish of 32 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm, but more than the avian reproductive NOEL of 25 ppm.

In the case of sweet corn in Florida and Georgia, the label permits retreatment as necessary, but do not apply more than 11 lbs ai/A (11 times at 1 lb ai/A or 22 times at 0.5 lb ai/A). The typical time interval between treatments is reported to be 3 days (Personal communication: Georgia Agricultural Extension Agent). The following table assesses risks posed by 11 applications at 1 lb ai/A.

**Risk Quotients for Corn**
**(Foliar Spray, 11 Aerial Applications at 1 lbs ai/A; 3-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 505 - 898 ppm | 102 ppm<br>147 ppm<br>647 ppm | 5.0 - 8.8<br>3.4 - 6.1<br>0.78 - 1.4 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 56 - 505 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.55 - 5.0<br>0.38 - 3.4<br>0.087- 0.78 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 56 - 505 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.12<br>0.087<br>0.017 |
| Mammalian Subacute Dietary $LC_{50}$ | 56 - 898 ppm | 1330 ppm | 0.042- 0.68 |
| Mammalian Reproduction NOEL | 56 - 898 ppm | 10 ppm | 5.6 - 90 |
| Avian Subacute Dietary $LC_{50}$ | 56 - 898 ppm | 136 ppm | 0.41 - 6.6 |
| Avian Reproduction NOEL | 56 - 898 ppm | 25 ppm | 2.2 - 36 |
| Freshwater Fish Acute $LC_{50}$ | 15.8 ppb | 1.8 ppb | 8.8 |
| Fish Reproduction NOEC | 7.4 - 12.8 ppb | 0.57 ppb | 13 - 22 |
| Aquatic Invertebrate Acute $LC_{50}$ | 15.8 ppb | 0.10 ppb | 160 |
| Freshwater Invert. Reproduction NOEC | 7.4 - 12.8 ppb | 0.04 ppb | 180 - 320 |
| Estuarine Fish Acute $LC_{50}$ | 15.8 ppb | 0.96 ppb | 16 |
| Estuarine Fish Reproduction NOEC | 7.4 - 12.8 ppb | 0.28 ppb | 26 - 46 |
| Estuarine Invertebrate Acute $LC_{50}$ | 15.8 ppb | 0.035 ppb | 450 |
| Estuarine Invert. Reproduction NOEC | 7.4 - 12.8 ppb | < 0.0046 ppb | > 1600 > 2800 |
| Estuarine Algae $EC_{50}$ | 15.8 ppb | 140 ppb | 0.11 |

**Risk Summary for Eleven Maximum, Post-emergent Aerial Spray Applications on Corn**: Chlorpyrifos aerially sprayed postemergence 11 times at 1.0 lb ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.017-8.8), subacute (0.042-0.68) and reproduction NOEL (5.6-90), avian subacute (0.41-6.6) and reproduction NOEL (2.2-36), freshwater fish acute (8.8) and reproduction NOEL (13-22), aquatic invertebrate acute (160) and reproduction NOEL (180-320), estuarine fish acute (16) and reproduction (26-46) and estuarine invertebrate acute (450) and reproduction NOEL (> 1600 > 2800). The algal risk quotient (0.11) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 29 ppm and whole fish of 20 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Risk Summary for Maximum Spray Applications to Corn**: Assessment of chlorpyrifos spray treatments to corn at pre-plant, emergence, whorl, tassel stages, and 11 weekly applications indicate high risks to many non-target aquatic and terrestrial animals in the above five treatment scenarios. Comparison of terrestrial risk quotients for the five spray treatment scenarios indicate wildlife risks in descending order: (3 lbs ai/A incorporated > 11 weekly applications at 1 lb ai/A and 3 biweekly applications at 1.5 lbs ai/A > ground and aerial applications at 1.5 lbs ai/A. Risk differences between the 5 treatments are 2 fold or less. Terrestrial risk quotients are actually lower for 11 applications at 1 lb ai/A than for 1 application of 3 lbs ai/A, because the 7-day halflife on vegetation results in maximum residues at twice the application rate. Risk quotients exceed the high risk LOCs for all wildlife categories, except mammalian granivores weighing 1,000 grams.

Aquatic risk quotients for the 5 treatments in descending order are 11 applications at 1 lb ai/A > 3 applications at 1.5 lbs ai/A > 1 aerial application at 1.5 lbs ai/A > 3 lbs ai/A soil incorporated > a ground application at 1.5 lbs ai/A. Risk differences between treatments are 12 fold or less. Risk quotients for a ground treatment at 1.5 lbs ai/A is about 28 percent lower than for an aerial applications at the same use rate. Risk quotients exceed high risk LOCs for all aquatic categories and in some cases, corn applications of chlorpyrifos pose potential risks via food chain effects to piscivorous mammals and birds.

The range of risk quotients for the five spray application methods assessed are as follows: mammalian herbivore acute (0.96-7.1), mammalian insectivore acute (0.11-4.0), mammalian granivore acute (0.007-0.88), mammalian subacute dietary (0.15-0.54), mammalian chronic (20-72), avian subacute dietary (1.5-5.3), avian chronic (8.1-29), freshwater fish acute (3.1-36) and chronic (4.7-89), aquatic invertebrate acute (55-650) and chronic (68-1300), estuarine fish acute (5.7-68) and chronic (9.6-180), estuarine invertebrate acute (160-1900) and chronic (>590->11,000), piscivorous mammalian dietary (0.006-0.074) and chronic (0.74-9.8), and piscivorous

avian dietary (0.054-0.72) and chronic (0.30-3.9).

Comparison of risk quotients for the 5 different applications indicates that the ground application has the lowest risks. Risk quotients for aquatic species from a ground application are about 28 percent lower than for a single aerial application at the same application rate. In all cases, applications of Lorsban 4 EC to corn poses acute and chronic risks to aquatic and terrestrial non-target organisms for all classes. If runoff occurs into shallower aquatic habitats than a 2-meter deep pond, aquatic exposure levels will increase, as will risk quotients. In the case of 3-foot standing waters and 6-inch marshes and swamps, the aquatic exposures and risk quotients will be slightly greater than for the 2-meter pond.

**Corn Field Study with Spray Applications**: Field studies were conducted in Iowa assessing risks of Lorsban 4 EC applications to corn with multiple applications. In general, the measured chlorpyrifos residue levels reported in the sprayed corn field study support the EECs used in this risk assessment. Chlorpyrifos levels found in the corn field study are compared to predicted EECs used in this risk assessment in the table below for spray treatments.

In the field study, chlorpyrifos was sprayed as Lorsban 4 EC, an emulsifiable concentrate formulation, to 4 fields (4 applications per field at 3, 1.5, 1.5, and 1.5 lbs ai/A each). Chlorpyrifos levels were measured in various environmental samples. Soils were sampled to a depth of 2.5 cm.

| CHLORPYRIFOS 4E APPLIED 4 TIMES TO CORN PREPLANT AT 3.0 LBS AI/A (SOIL INCORPORATED TO UNSPECIFIED DEPTH) AND THREE TIMES AT 1.5 LBS AI/A (EMERGENCE, WHORL, & TASSEL) | | | | |
|---|---|---|---|---|
| Substrate (1, 2, 3 & 4 Appls.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EFED Initial EEC |
| 1st Soil (2.5 cm) | 5.53 ppm | 3.21-9.11 ppm | 14.8[a] ppm | 6.6 ppm |
| 2nd Soil (2.5 cm) | 5.66 ppm | 3.20-7.41 ppm | 9.45 ppm | 3.3 ppm |
| 3rd Soil (2.5 cm) | 4.15 ppm | 2.99-5.27 ppm | 8.37 ppm | N/A |
| 4th Soil (2.5 cm) | 2.00 ppm | 1.11-4.41 ppm | 8.38 ppm | N/A |
| 1st Crop Foliage | N/A | N/A | N/A | N/A |
| 2nd Crop Foliage | 358 ppm | 151-492 ppm | 544 ppm | 203 ppm |
| 3rd Crop Foliage | 193 ppm | 149-288 ppm | 418 ppm | N/A |
| 4th Crop Foliage | 104 ppm | 39-166 ppm | 257 ppm | 266 ppm |
| 1st Noncrop Foliage | 2.70 ppm | n.d.-5.66 ppm | 10.9 ppm | 20 ppm |
| 2nd Noncrop Foliage | 1.87 ppm | n.d.-5.81 ppm | 9.83 ppm | 10.1 ppm |

| | | | | |
|---|---|---|---|---|
| 3rd Noncrop Foliage | 29.6 ppm | 10.5-59.5 ppm | 129 ppm | 15.2 ppm |
| 4th Noncrop Foliage | 33.8 ppm | 0.68-92.9 ppm | 173 ppm | 17.7 ppm |
| 1st Invertebrates | n.d. | n.d. | n.d. | 45 ppm |
| 2nd Invertebrates | 0.82 ppm | n.d.-0.88 ppm | 11.5[b] ppm | 15.2[c] ppm |
| 3rd Invertebrates | no data | N/A | N/A | 33.9 ppm |
| 4th Invertebrates | n.d. | n.d. | 7.33[d] ppm | 19.4[e] ppm |
| 1st Water (ppb) | 2.85 ppb | 2.55-3.00 ppb | 6.32[f] ppb | 8.7-11[i] ppb |
| 2nd Water (ppb) | 66.9 ppb | n.d.-97.6 ppb | 115 ppb | 6.8- 7.7[j] ppb |
| 3rd Water (ppb) | no data | no data | no data | N/A |
| 4th Water (ppb) | n.d.[g] | n.d. | 2.20[h] ppb | 21.5-24[k] ppb |

[a] Highest concentrations were found in soil at later times (i.e., 16.7 ppm on Day 4, and 22.8 ppm on Day 7)
[b] Highest concentration was found in field invertebrates on Day 4 (11.5 ppm)
[c] Concentration estimated for Day 4 after the first application
[d] Highest concentration was found in field invertebrates on Day 7 (7.33 ppm)
[e] Concentration estimated for Day 7 after the third application
[f] Highest concentration was found on Day 14 (6.32 ppb)
[g] n.d. -- concentration is below the level of quantification (1.0 ppb)
[h] Highest concentration was found on Day 7
[i] Aquatic EECs are for 96-hours and peak conc. for ground spray (PRZM3-EXAMS)
[j] Aquatic EECs are for 96-hours and peak concentrations for one aerial spray application (GENEEC Model)
[k] Aquatic EECs are for 96-hours and peak concentration for three aerial spray applications (GENEEC Model)

Estimated terrestrial EECs used in the corn risk assessment generally occur in the range of the measured chlorpyrifos levels reported in the Iowa, corn field study. Initial, mean measured soil concentrations which ranged from 1.11 to 9.11 ppm span the EECs of 3.3 and 6.6 ppm that are estimated with the soil dilution nomograph for soils when corrected for soil cores 2.5 cm deep. Chlorpyrifos concentrations in soil were not used in this risk assessment. Maximum, initial measured chlorpyrifos levels on crop foliage ranged from 257 ppm to 544 ppm equal or exceed residue levels of 203 and 266 ppm predicted on foliage by values in Fletcher *et al*. (1994). Maximum, initial measured chlorpyrifos levels on adjacent non-crop foliage ranged from 9.83 to 173 ppm are half, equal to, or exceed predicted levels of 10.1 to 17.7 ppm. Invertebrate species analyzed for chlorpyrifos were not identified, hence it is unclear whether they were sprayed directly or may have been covered by soil or migrated into the treated area after the application. Comparison of measured chlorpyrifos levels on invertebrates were within 1.3 to 2.7 fold of predicted levels for the same post-treatment periods.

Comparison of mean measured, aquatic concentrations (n.d. to 97.6 ppb) to estimated aquatic EECs (6.8 to 24 ppb) generally 3 to 5 times lower than the predicted EECs, but in one case, the mean measured level (115 ppb) was 15 times more than the predicted EEC. Mean measured water concentrations frequently exceed the acute fish $LC_{50}$ and acute aquatic invertebrate $EC_{50}$

values for sensitive species.

In the same manner that the Iowa corn field study support EECs, terrestrial risk quotients for spray treatments on corn are supported by carcasses testing positive for chlorpyrifos and animals showing cholinesterase behavior. Twenty-seven carcasses were found including 13 birds, 9 small mammals, 4 reptiles and 1 amphibian. Only four carcasses were analyzed for chlorpyrifos; a robin which showed cholinesterase behavior was caught and died and a field mouse; both tested positive for chlorpyrifos, a vole and a shrew tested negative. A second robin showing cholinesterase behavior was also caught and survived, but it is counted as affected by chlorpyrifos.

**Granular Preplant Broadcast, Soil Incorporated Corn Use**: The typical granular formulation used on corn is Lorsban 15G (15% active ingredient). Directions for use on corn on registered labels allow chlorpyrifos application at 1 to 2 lbs ai/A evenly distributed over the treated area and incorporated into the soil using an S tine, C tine, disc cultivator, or other suitable incorporation equipment set to cut to a depth of 4 to 6 inches. It is assumed that only 15 percent of the granules are available to wildlife following soil incorporation. The risk quotients for mammalian herbivores, insectivores, and granivores are combined, because the number of granules per $ft^2$ available to all mammals is equal. Risk quotients for granular pre-plant use on corn are assessed in the following table.

**Granular Risk Quotients for Corn**
**(Pre-Plant, Ground Broadcast; 1 Application at 2 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 3.1 $mg/ft^{2}$* | 1.5 mg<br>3.4 mg<br>97 mg | 2.1<br>0.91<br>0.032 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 3.1 $mg/ft^{2}$* | 0.28 mg | 11 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 1.66 ppb | | 0.92 |
| Fish Reproduction NOEC | 0.57 ppb | 0.81 -1.44 ppb | | 1.4 - 2.5 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 1.66 ppb | | 17 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 0.81 -1.44 ppb | | 20 - 36 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 1.66 ppb | | 1.7 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 0.81 -1.44 ppb | | 2.9 - 5.1 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 1.66 ppb | | 47 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 0.81 -1.44 ppb | | >180 - >310 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 1.66 ppb | | 0.012 |

$$* \text{ mg ai/foot}^2 = \frac{2 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb} \times 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}} = 3.1 \text{ mg/ft}^2$$

**Risk Summary for Pre-plant Granular Broadcast Applications at 2 lbs ai/A on Corn**: Chlorpyrifos granules broadcast at pre-plant at 2 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.032-2.1), avian acute (11), freshwater fish acute (0.92) and reproduction NOEL (1.4-2.5), aquatic invertebrate acute (17) and reproduction NOEL (20-36), estuarine fish acute (1.7) and reproduction (2.9-5.1) and estuarine invertebrate acute (47) and reproduction NOEL (> 180 > 310). The algal risk quotient (0.012) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 3.2 ppm and whole fish of 2.2 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**At-Plant Granular Band Corn Uses**: Lorsban 15 G may be applied at 1.2 oz. ai./1,000 feet of row (band, T-band or in-furrow) and at 1.8 oz. ai./1,000 feet of row in case of severe infestations. In conventional, minimum and no-till corn, the granules are placed in a 6 or 7-inch wide band over the row behind the planter shoe, in front of the press wheel, and then incorporated into the top 1 or 2 inches of soil using tines or chains or other suitable equipment. For T-band treatments, granules are applied over an open seed furrow and in conventional and minimum-till corn, granules are incorporated into the top 0.5-1 inch of soil using suitable equipment. For in-furrow treatment, granules are directed into the planter shoe with the seed or place the applicator tube directly behind the planter shoe so that the granules drop into the seed furrow or the granular band applicator is placed behind the planter shoe so that the granules fall on the soil surface and into the open seed furrow and are covered with soil. From this description it is assumed that 15 to 100 percent of the granules are available to wildlife from band treatment with press wheel (unincorporated) and T-band (unincorporated) and 1 percent are available from in-furrow treatment. Band width should be 0.5 ft as worst case, but 0.6 ft was used to conform to the corn cluster analysis.

Row spacing for all corn crops are assumed to be 30 inches. Band widths for corn are 6 to 7 inches and 7 to 10 inches. Risks to wildlife are considered to be greatest when a given application rate is applied in a narrower band width (more concentrated); the narrowest band width is assumed, if it is not given. In the case of corn, a 7-inch band width was used to replicate the same risk assessment assumptions as in the corn cluster.

When application rates are expressed as ounces/1000 feet of row, the application rate in lbs ai/A must be determined in order to calculated the aquatic EEC's with the GENEEC model. The following formula can be used to calculate lbs ai/A from banded applications expressed as oz. ai/1000 feet of row, because with the exception of runoff reductions for soil incorporation, there is no reason to suspect that aquatic EEC's are affected differently by banded treatments compared to even distribution over the field.

In order to calculate aquatic EECs, oz. ai/1000 feet of row must be converted into lbs ai/A. The formula below makes that conversion.

$$\text{lbs ai/A} = \frac{1.8 \text{ (oz. ai/1000 feet of row)} \times 43560 \text{ ft}^2/\text{A}}{16 \text{ oz./lb} \times 1000 \text{ ft} \times 2.5 \text{ row spacing (ft.)}} = 2 \text{ lbs ai/A}$$

In the corn cluster, an at-plant scenario with a banded treatment with Lorsban 15 G applied at 1.5 lbs ai/A was assessed for risks. The granules are placed in a 6- or 7-inch wide band over the row behind the planter shoe, in front of the press wheel, and incorporated into the top 1-inch of soil using tines or chains or other suitable equipment. For consistency with the corn cluster assessment, a 7-inch wide band was used in this assessment. The 6-inch wide band would yield slightly higher terrestrial risk quotients than for 7-inch wide bands, because the granules are more dense as computed for the $LD_{50}$s per square foot risk assessment. Risk quotients are assessed in the following table.

**Granular Risk Quotients for Corn**
**(At-Plant, 7-inch Band or T-Band; 1 Application at 1.8 oz./1,000 Feet of Row; 1-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on Formula** and GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 12.8 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 8.5<br>3.8<br>0.13 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 12.8 mg/ft$^2$* | 0.28 mg | 46 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 6.64 ppb | | 3.7 |
| Fish Reproduction NOEC | 0.57 ppb | 3.36-5.78 ppb | | 5.9 - 10 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 6.64 ppb | | 66 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 3.36-5.78 ppb | | 84 - 140 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 6.64 ppb | | 6.9 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 3.36-5.78 ppb | | 12 - 21 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 6.64 ppb | | 190 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 3.36-5.78 ppb | | >730 > 1300 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 6.64 ppb | | 0.047 |

* mg ai/ft$^2$ = $\frac{(1.8 \text{ oz ai/1000 ft row}) \times 28{,}349 \text{ mg/oz.} \times 15\% \text{ exposed}}{1{,}000 \text{ feet row} \times \text{band width (0.6 ft.)}}$ = 12.8 mg ai/ft$^2$

** lbs ai/A = $\frac{1.8 \text{ (oz. ai./1000 feet of row)} \times 43560 \text{ ft}^2/\text{A}}{16 \text{ oz./lb} \times 1000 \text{ ft} \times 2.5 \text{ row spacing (ft.)}}$ = 2 lbs ai/A

**Risk Summary for Maximum At-plant, Granular Banded Corn Use**: Chlorpyrifos granules applied in a banded treatment at-plant at 1.8 oz. ai per 1,000 foot row and soil incorporated to a

depth of 1 inch yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.13-8.5), avian acute (46), freshwater fish acute (3.7) and reproduction NOEL (5.9-10), aquatic invertebrate acute (66) and reproduction NOEL (84-140), estuarine fish acute (6.9) and reproduction (12-21) and estuarine invertebrate acute (190) and reproduction NOEL (> 730 > 1300), and estuarine algae (0.047).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 13 ppm and whole fish of 9.3 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Postplant Corn Uses**: Three types of postplant corn treatments are cited on the Lorsban 15 G label. At cultivation, granules may be placed at the base of the plant on both sides of the row just ahead of the cultivation shovels and "cover the soil" at 0.9-1.2 oz. ai/1000 feet of row. Or granules at 0.75-0.975 lbs ai/A may be uniformly broadcast granules over the corn plants by aerial application at whorl and tassel stages or placed into the corn whorls by ground application. Risk quotients for the banded treatment is addressed in the above table, but the risk quotients are one-half the values in the table due to the lower application rate. The table below calculates risk quotients for two broadcast applications (i.e., whorl and tassel treatments). For the $LD_{50}$ per $ft^2$ assessment, it is assumed that 50% of the granules at intercepted by plant surfaces (50% reach the ground) and that no granules are left 2 weeks after the previous applications.

**Granular Risk Quotients for Corn**
**(Postemergence Broadcast, 2 Applications at 0.975 ai/A; 14-Day Interval; 50% Interception by plant)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 5 mg/$ft^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 3.3<br>1.5<br>0.05 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 5 mg/$ft^2$* | 0.28 mg | 18 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 6.35 ppb | | 3.5 |
| Fish Reproduction NOEC | 0.57 ppb | 3.1- 5.5 ppb | | 5.4 - 9.6 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 6.35 ppb | | 64 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 3.1- 5.5 ppb | | 78 - 140 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 6.35 ppb | | 6.6 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 3.1- 5.5 ppb | | 11 - 20 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 6.35 ppb | | 180 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 3.1- 5.5 ppb | | >670 > 1200 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 6.35 ppb | | 0.045 |

* mg ai/foot$^2$ = $\frac{0.975 \text{ lb ai/A X } 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2\text{/A}}$ = 10.15 mg/ft$^2$ / 2 (50% plant interception) = 5 mg/ft$^2$

**Risk Summary for Two Maximum Postemergence, Granular Aerial Applications on Corn**: Chlorpyrifos granules aerially applied to foliar corn at 0.975 lbs ai/A yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.05-3.3), avian acute (18), freshwater fish acute (3.5) and reproduction NOEL (5.4-9.6), aquatic invertebrate acute (64) and reproduction NOEL (78-140), estuarine fish acute (6.6) and reproduction (11-20) and estuarine invertebrate acute (180) and reproduction NOEL (> 670 > 1200). The algal risk quotient (0.045) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 17 ppm and whole fish of 12 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Risk Summary for Maximum Granular Applications to Corn**: Assessment of chlorpyrifos granular treatments to corn at pre-plant, at plant, at cultivation, whorl, and tassel stages, indicate high risks to many species from all five treatment scenarios. Comparison of terrestrial risk quotients for the five granular treatment scenarios indicate wildlife risks in descending order: (at-plant at 1.8 oz./1,000 feet incorporated > whorl and tassel aerial applications at 0.975 lbs ai/A > at cultivation at 1.2 oz./1,000 feet incorporated > pre-plant at 2 lbs ai/A incorporated. Risk differences between the 5 treatments are about 5 fold or less. Risk quotients exceed the high risk LOCs for all wildlife categories, except mammals weighing 1,000 grams.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 12 ppm and whole fish of 8.5 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Aquatic risk quotients for the 5 treatments in descending order are the same as for terrestrial species. Risk differences between treatments are also about 5 fold or less. Risk quotients exceed high risk LOCs for all aquatic categories, except for piscivorous categories.

The range of risk quotients for the five granular application methods assessed are as follows: mammalian acute (0.032-11), avian acute (11-61), freshwater fish acute (0.9-4.8) and chronic (1.4-13), aquatic invertebrate acute (17-86) and chronic (20-190), estuarine fish acute (1.7-9.0) and chronic (2.9-27), estuarine invertebrate acute (47-250) and chronic (>176->1,600). Except for the pre-plant, soil incorporated uses, the acute LC50 values for both fish and invertebrate species were exceeded for over 56 days by the EEC predicted for granular applications on corn.

Food Chain Effects: Estimates of chlorpyrifos residue levels in fish viscera range 3.2 to 98 ppm and residues in whole fish range from 2.2 to 68 ppm. These residues levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but only one value is less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but two of the five uses are more than the avian reproductive NOEL of 25 ppm.

In all cases, applications of Lorsban 15G to corn poses acute risks to small mammals and birds, and acute and chronic risks to aquatic non-target organisms for all categories, and in some cases there are risks to piscivorous mammals and birds. Seventeen carcasses were collected from corn fields treated with Lorsban 15G in a Iowa terrestrial field studies including 9 birds, 7 mammals, and i amphibian. Only 3 out of the 17 carcasses were analyzed for chlorpyrifos. One shrew tested positive for chlorpyrifos. Another shrew and a rabbit showed cholinesterase behavior.

**Corn Field Study with 15% Granular Applications**: Granular chlorpyrifos residue levels measured in an Iowa, corn field study are comparable to the predicted EECs in the following table using the same EEC methodology as in the risk assessment tables above. In the field study, chlorpyrifos was applied as Lorsban 15 G, a granular formulation, to 4 fields (3 applications per field; 1.1 to 2.9 kg/ha [1 - 2.6 lbs ai/A]). Soils were sampled to a depth of 2.5 cm.

CHLORPYRIFOS 15G APPLIED THREE TIMES TO CORN
AT-PLANT AT 2.6 LBS AI/A (SOIL INCORPORATED BY PRESS WHEEL)
AND TWO APPLICATIONS AT 0.975 LBS AI/A (AT WHORL & TASSEL)

| Substrate (1, 2 & 3 Appls.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EFED Initial EEC |
|---|---|---|---|---|
| 1st Soil (25 cm) | 22.4 ppm | 9.06-42.2 ppm | 95.6[a] ppm | 5.72 ppm |
| 2nd Soil (25 cm) | 2.87 ppm | 0.16-5.18 ppm | 14.5[b] ppm | 2.2 ppm |
| 3rd Soil (25 cm) | 6.36 ppm | 3.17-11.9 ppm | 30.6 ppm | 4.4 ppm |
| 1st Invertebrates | n.d. | n.d. | n.d. | N/A |
| 2nd Invertebrates | no data | no data | no data | no data |
| 3rd Invertebrates | 4.95 ppm | 3.70-5.79 ppm | 7.83[c] ppm | N/A |
| 1st Water (ppb) | n.d. | n.d. | n.d. | 7.4-8.6[d] ppb |
| 2nd Water (ppb) | no data | no data | no data | 2.8-3.2[e] ppb |
| 3rd Water (ppb) | n.d. | n.d.-1.46[f] ppb | 1.80[f] ppb | 5.5-6.35[e] ppb |

[a] Several samples taken on Day 7 were higher than any soil conc. on Day 0
[b] Highest conc. found on Day 4 and mean conc. was higher 5.61 versus 2.87 ppm

[c] Highest conc. found on Day 7 and mean conc. was higher 4.95 versus 2.02 ppm
[d] Aquatic EECs are for 96-hours and peak concentrations for broadcast (although a press wheel may reduce runoff by firming the soil, it does not constitute soil incorporation)
[e] Aquatic EECs are for 96-hours and peak concentrations for broadcast
[f] Measurable levels in water were found only on Day 7; fewer samples were collected on all other sampling days

Terrestrial samples measured in the corn granular field study do not correspond to the exposure method used for granular risk assessment (i.e., mg per square foot). Mean measured chlorpyrifos levels in soil (i.e., 0.16 to 42.2 ppm) bracket the predicted EECs (2.2 to 5.72 ppm) based on the soil dilution nomograph. While soil organisms may be contaminated by pesticides, the agency lacks a methodology to predict EECs for invertebrates exposed to granular pesticides.

Comparison of mean measured, aquatic concentrations (n.d. to 1.46 ppb) to estimated aquatic EECs (6.8 to 24 ppb) generally 3 to 5 times lower than the predicted EECs. Two out of three measured water concentrations equal the acute fish $LC_{50}$ and all three samples exceed acute aquatic invertebrate $EC_{50}$ values for sensitive species.

Again, field study results support both the EECs and risk quotients for corn treated with Lorsban 15 G treatments. Seventeen carcasses were found on the granular-treated fields. Only four carcasses were analyzed for chlorpyrifos. A brown thrush was hit by a car, analyzed and found negative for chlorpyrifos. The carcass of a field mouse, *Peromyscus* sp. contained 0.7 ppm. A short-tailed shrew contained 2.1 ppm in its internal tissues; a second shrew exhibited behaviors typical of cholinesterase inhibition; both were considered positive for chlorpyrifos effects. An eastern cottontail rabbit was found slightly affected (i.e., showing behavior indicating cholinesterase inhibition). While the rabbit could not be caught, it was considered positive effect for chlorpyrifos. An American toad was analyzed, but it contained no chlorpyrifos. Four out of six animals evaluated, 67 percent, either tested positive for chlorpyrifos or showed behavior indicative of cholinesterase inhibition.

Carcass detectability tests showed that searchers might be expected to find few casualties compared to the number of animals killed. The highest combined recovery rates generally decreased as the crop grew large (i.e., 14.3 % preplant and at-plant, 26.1 % at emergence, 13.8 % at whorl, and 8.7% at tassel). Recovery levels in the three search areas were generally higher for the interior, then field perimeter, and lowest in adjacent habitats. Preplant and at-plant recovery rates were 18.3 % in the interior, 18.3 % perimeter, and 3.6 % adjacent. Recovery rates at emergence were 26.1% in the interior, 41.5 % perimeter, and 8.0 % in adjacent areas. Recovery rates at whorl were 17.5 % in the interior and slightly less in the perimeter and adjacent areas. At the tassel stage, all recovery rates were similar for all areas (8.7 %).

**Comparison of Maximum Risk Quotients for Corn Formulations:** Comparison of terrestrial risks for liquid and granular formulations is difficult, because the exposures are different and risks are expressed in different units. Assuming that the lower granular application rates for each growth stage represent equal efficacy as the respective spray treatments, the risk comparisons are as follows. Preplant risk quotients for granular use are 2 to 3.5 fold lower than sprays for mammals; 20 to 36 fold higher than sprays for birds; and 4.3 lower than sprays for aquatic

organisms. At plant risk quotients for granular use are 3.1 to 5.5 fold higher than spray use for mammals; 23 to 41 fold higher for birds; and 3.1 fold lower for aquatic organisms. Whorl and tassel risk quotients for granular use are similar to spray treatment for small mammals; 14 to 24 fold higher for birds; and 2.4 fold less for aquatic organisms.

A comparison of risk quotients for granular and spray uses are about equal for small mammals; consistently higher with granules for birds; and about equal or less with granules for aquatic organisms.

The most important factor affecting terrestrial risks is the application rate and the amount available on the substrate surface. That is, risks to terrestrial species are more affected by high application rates than multiple applications. For example, residue levels on short grass after 1 application at 3 lbs ai/A is 720 ppm compared to 480 ppm for 11 applications at 1 lb ai/A. The reason is the relatively short half-life of 7-days on vegetation and the 7-day interval between treatments.

Risk quotients for aquatic species are lower for ground applications compared to aerial uses. Risk quotients for aquatic species for all application methods exceed levels of concern and $LC_{50}$ values for all aquatic categories, except piscivorous mammals and birds. Acute risk quotients are as high as 36 and 68 for the fish, 650 to 1900 for aquatic invertebrates, 0.05 to 0.07 for mammalian piscivores, and 0.5 to 0.7 for avian piscivores. Reproductive risk quotients are as high as 89 to 180 for fish, 1300 to 11,000 for invertebrates, and 4.9 and 3.9 for piscivorous mammals and birds, respectively. The highest aquatic risks occurred from 11 applications at 1 lb ai/A. The most important factor in aquatic exposures are the total amount applied, irrespective of the number of applications.

**Typical Corn Use**: According to BEAD, the typical use rate on corn is a single preplant, granular application at an average of 1.1 lbs ai/A. Following the broadcast application, the granules are incorporated into the soil. It is assumed that only 15 percent of the granules are available to wildlife. In the corn cluster, risk quotients for granular uses on corn were assessed for two states, Iowa and Mississippi and are included here to provide a sense of variability in the aquatic risks in different regions of the country. The EECs have been updated with an improved PRZM3-EXAMS Model. Risk quotients for granular use on corn in these two states are assessed in the following two tables.

**Granular Risk Quotients for Corn (Iowa)**
**(Pre-Plant, Ground Broadcast; 1 Application at 1.1 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 1.7 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 1.1<br>0.50<br>0.018 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 1.7 mg/ft$^2$* | 0.28 mg | 6.1 |

| | | | | |
|---|---|---|---|---|
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 3.4 ppb | | 1.9 |
| Fish Reproduction NOEC | 0.57 ppb | 1.4 - 2.6 ppb | | 2.5 - 4.6 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 3.4 ppb | | 34 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.4 - 2.6 ppb | | 35 - 65 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 3.4 ppb | | 3.5 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.4 - 2.6 ppb | | 5.0 - 9.3 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 3.4 ppb | | 97 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.4 - 2.6 ppb | | >300 - >570 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 3.4 ppb | | 0.024 |

* mg ai/foot$^2$ = $\frac{1.1 \text{ lb ai/A X } 453{,}590 \text{ mg/lb X } 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}}$ = 1.7 mg/ft$^2$

**Risk Summary for a Granular Broadcast Application on Corn in Iowa**: Chlorpyrifos granules broadcast at pre-plant at 1.1 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.018-1.1), avian acute (6.1), freshwater fish acute (1.9) and reproduction NOEL (2.5-4.6), aquatic invertebrate acute (34) and reproduction NOEL (35-65), estuarine fish acute (3.5) and reproduction (5.0-9.3) and estuarine invertebrate acute (97) and reproduction NOEL (> 300 > 570), and estuarine algae (0.024).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 5.5 ppm and whole fish of 3.8 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are also less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm. For a single typical use on corn, chlorpyrifos would not seem to be a concern for animals feeding on fish and other aquatic organisms.

**Granular Risk Quotients for Corn (Mississippi)**
**(Pre-Plant, Ground Broadcast; 1 Application at 1.1 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 1.7 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 1.1<br>0.50<br>0.018 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 1.7 mg/ft$^2$* | 0.28 mg | 6.1 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 3.9 ppb | | 2.2 |
| Fish Reproduction NOEC | 0.57 ppb | 1.6 - 3.1 ppb | | 2.8 - 5.4 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 3.9 ppb | | 39 |

| | | | | |
|---|---|---|---|---|
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.6 - 3.1 ppb | | 40 - 78 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 3.9 ppb | | 4.1 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.6 - 3.1 ppb | | 5.7 - 11 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 3.9 ppb | | 110 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.6 - 3.1 ppb | | >350 - >670 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 3.9 ppb | | 0.028 |

$$* \text{ mg ai/foot}^2 = \frac{1.1 \text{ lb ai/A X } 453{,}590 \text{ mg/lb X } 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}} = 1.7 \text{ mg/ft}^2$$

**Risk Summary for a Granular Broadcast Application on Corn in Mississippi**: Chlorpyrifos granules broadcast at pre-plant at 1.1 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients in Mississippi exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients for Mississippi are mammalian acute (0.018-1.1), avian acute (6.1), freshwater fish acute (2.2) and reproduction NOEL (2.8-5.4), aquatic invertebrate acute (39) and reproduction NOEL (40-78), estuarine fish acute (4.1) and reproduction (5.7-11) and estuarine invertebrate acute (110) and reproduction NOEL (> 350 > 670), and estuarine algae (0.028). The acute LC50 value for aquatic invertebrate species were exceeded for over 90 days by the EEC predicted for a typical pre-plant, granular application on corn.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 6.2 ppm and whole fish of 4.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Comparison of the risk quotients for applications in Iowa and Mississippi indicate that terrestrial risk quotients are the same. Based on local differences in risks based on different soil types and weather conditions found in Iowa and Mississippi, aquatic risk quotients in Iowa are about 14 percent lower than RQs in Mississippi. The typical use rate on corn at 1.1 lbs ai./A applied as a T-band treatment at-plant yields risk quotients higher than the above RQ values for Iowa (2 fold) and Mississippi (1.7 fold).

**Risk Summary for Corn Uses**: Application of spray and granular formulations yield risk quotients which indicate high acute risks to small terrestrial mammals, birds and aquatic organisms, except estuarine algae. The high risk quotients are confirmed by mortality and cholinesterase effects on small mammals and birds in the corn field study. The field study did not monitor for aquatic effects, but measured chlorpyrifos residues in water adjacent to treated fields ranged from non-detect to 115 ppb. The extent of adverse effects on local populations of terrestrial wildlife is difficult to estimate. Many carcasses and some effected wildlife species were found in carcass searches which covered only a small portion of the treated areas. Carcass

recovery studies suggest that much larger numbers of wildlife are not found in search areas. If the percentage of casualties testing positive for chlorpyrifos residues reflect the percentage of all casualties found, approximately 60 percent of the casualties are affected by chlorpyrifos. If the 60 percent, chlorpyrifos-affected wildlife is extrapolated to the total local population and corrected for percent recovery and percent of treated area, covered in carcass searches, the estimate of number of wildlife affected by chlorpyrifos should begin to raise concerns about non-target species. The duration of time (i.e., 56 to 90 days) that EECs for several use patterns on corn exceed the acute LC50 values for fish and/or aquatic invertebrate species should also raise concerns for aquatic species.

**(ii) Cover crops (alfalfa, clover and grass grown for seed, mint, and wheat)**

Chlorpyrifos applications to cover crops, such as alfalfa, clover for seed, grass for seed, and wheat are largely limited to liquid formulations. The foliar spray rates are 0.5 lbs ai/A (2 treatments) for wheat and 0.25 to 1.0 lb ai/A (once per cutting and up to 4 times per season) aerially sprayed on alfalfa. Ground applications on clover grown for seed are 2.0 lbs ai/A preplant and foliar sprays (limited to Oregon). Ground and aerial applications to grass grown for seed use are sprayed three times at 1 lb ai/A (use limited to CA, ID, OR, SD, and WA). Mint uses include 2 lbs ai/A applications for a pre-plant, soil incorporated treatment (limited to Oregon) and for a foliar, ground broadcast or sprinkler irrigation treatment (1 application each).

Runoff from foliar applications to cover crops is expected to be reduced compared to crops grown on plowed or bare ground. The GENEEC and PRZM3-EXAMS Models estimate EECs for row crops, but data on runoff are unavailable to model EECs for vegetative ground cover. The degree to which ground cover reduces runoff and yields lower EECs is unknown. Hence, the aquatic risk quotients in the following tables for these cover crops are higher than anticipated.

**Alfalfa Uses**: Alfalfa is in the top five crops for chlorpyrifos usage with about 4.9 percent of the total agricultural poundage. Chlorpyrifos is applied to an average of about 3 percent (likely maximum of 3 percent treated) of the approximately 24,000,000 acres of alfalfa in the U.S. According to BEAD, the typical average chlorpyrifos usage on alfalfa is 1.1 applications at 0.7 lbs ai/A on approximately 670,000 to 840,000 acres. The leading states using chlorpyrifos in decreasing order of poundage are California, Pennsylvania, Missouri, Illinois, Kansas, and Colorado which represent about 55% of the chlorpyrifos used on alfalfa.

Wildlife utilization of alfalfa fields is high including a broad diversity of avian and mammalian species. Alfalfa fields are heavily used by a large number of wildlife in a many states. Ring-necked pheasants, grouses, partridges, quail, sandhill crane, ducks, geese, mourning dove, songbirds, rabbits, groundhogs, muskrats, deer and elk feed in alfalfa fields to a medium to high degree. While it is unlikely that deer and elk might be adversely affected, because of their large size, chlorpyrifos applications to alfalfa could adversely affect many of the other species that consume food items (such as seeds, insects and vegetation in treated fields. Many of

the avian species also nest in alfalfa fields.

Risk assessments for alfalfa treatments have been made using maximum application rates as an initial screen for adverse effects and a refinement with typical use rate. Risk quotients have be estimated for a granular at-plant application, limited to Missouri and four post-emergent foliar spray treatments.

Alfalfa granular use: Chlorpyrifos granules are applied to alfalfa at-planting at 1.0 lb ai/A in-furrow and incorporated into the soil. Only one application can be made with granules per season. Four applications of Lorsban 4 EC per year can be made per season. The following table summarizes risks from an alfalfa at-plant granular use.

**Granular Risk Quotients for Alfalfa Limited to Missouri**
**(At-plant, In-furrow Treatment, 1 Application at 1.0 lb ai/A; Assume 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 1.6 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 1.1<br>0.47<br>0.016 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 1.6 mg/ft$^2$* | 0.28 mg | 5.7 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 0.83 ppb | | 3.5 |
| Fish Reproduction NOEC | 0.57 ppb | 0.4-0.72 ppb | | 0.70 - 1.3 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 0.83 ppb | | 8.3 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 0.4-0.72 ppb | | 10 - 18 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 0.83 ppb | | 0.86 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 0.4-0.72 ppb | | 1.4 - 2.6 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 0.83 ppb | | 24 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 0.4-0.72 ppb | | >87 > 160 |

* mg ai/foot$^2$ = $\frac{\text{1.0 lb ai/A X 453,590 mg/lb X 15\% exp.}}{\text{43,560 ft}^2\text{/A}}$ = 1.6 mg/ft$^2$

**Risk Summary for Maximum Alfalfa Pre-plant Uses**: Risk quotients for chlorpyrifos uses on alfalfa as pre-plant granular exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.016 to 1.1), avian subacute (1.5-2.6), fish acute (3.5) and reproduction (0.70-1.3), acute aquatic invertebrate (8.3) and reproduction (10-18), estuarine fish acute (0.86) and reproduction (1.4-2.6), and estuarine invertebrate acute (24) and reproduction (> 87 > 160).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 1.6 ppm and whole fish of 1.1 ppm. These levels are less than the mammalian subacute $LC_{50}$

value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Alfalfa spray use: Chlorpyrifos may be sprayed on foliar alfalfa four times per season (once per cutting) at 0.25-1 lb ai/A per treatment. The maximum of usage is limited to 4 lbs ai/A per season. Treatments are applied by ground, sprinkler irrigation, or aerial equipment. For terrestrial exposures, it is assumed that the aerial applications are spaced about 6 weeks apart and that residues from previous applications are inconsequential. Aquatic EECs have been calculated using the GENEEC Model. The GENEEC Model assumes runoff levels from field crops with bare ground rather than for cover crops, like alfalfa. Since cover crops reduce erosion and runoff levels, the risk estimates for aquatic organisms may be overestimated. The following table summarizes risk quotients for 4 aerial, foliar spray applications.

**Risk Quotients for Alfalfa**
**(Postemergent/foliar, Aerial Spray; 4 Applications at 1.0 lbs ai/A; 42-Day Interval)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 135 - 240 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.3 - 2.4<br>0.92 - 1.6<br>0.21 - 0.37 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 - 135 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.15 - 1.3<br>0.10 - 0.92<br>0.023- 0.21 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.032<br>0.023<br>0.005 |
| Mammalian Subacute Dietary $LC_{50}$ | 15 - 240 ppm | 1330 ppm | 0.011- 0.18 |
| Mammalian Reproduction NOEL | 15 - 240 ppm | 10 ppm | 1.5 - 24 |
| Avian Subacute Dietary $LC_{50}$ | 15 - 240 ppm | 136 ppm | 0.11 - 1.8 |
| Avian Reproduction NOEL | 15 - 240 ppm | 25 ppm | 0.6 - 9.6 |
| Freshwater Fish Acute $LC_{50}$ | 18 ppb | 1.8 ppb | 10 |
| Fish Reproduction NOEC | 8.7 - 16 ppb | 0.57 ppb | 15 - 28 |
| Aquatic Invertebrate Acute $LC_{50}$ | 18 ppb | 0.10 ppb | 180 |
| Freshwater Invert. Reproduction NOEC | 8.7 - 16 ppb | 0.04 ppb | 220 - 400 |
| Estuarine Fish Acute $LC_{50}$ | 18 ppb | 0.96 ppb | 19 |
| Estuarine Fish Reproduction NOEC | 8.7 - 16 ppb | 0.28 ppb | 31 - 57 |
| Estuarine Invertebrate Acute $LC_{50}$ | 18 ppb | 0.035 ppb | 510 |
| Estuarine Invert. Reproduction NOEC | 8.7 - 16 ppb | < 0.0046 ppb | >1900 > 3500 |

**Risk Summary for Maximum Alfalfa Post-emergent Use**: Risk quotients for 4 foliar spray

applications exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.005 to 2.4), subacute (0.011-0.18) and reproduction (1.5-24), avian subacute (0.11-2.6) and reproduction (0.6-9.6), fish acute (10) and reproduction (15-28), acute aquatic invertebrate (180) and reproduction (220-400), estuarine fish acute (19) and reproduction (31-57), and estuarine invertebrate acute (510) and reproduction (> 1900 > 3500).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 34 ppm and whole fish of 24 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

Typical Alfalfa Use: According to BEAD, the typical use rate on alfalfa is 1.1 post-emergent, foliar spray applications at an average of 0.7 lbs ai/A on approximately 670,000 to 835,000 acres. Risk quotients for a typical, foliar spray application on alfalfa are estimated in the following table.

**Risk Quotients for Typical Use on Alfalfa**
**(Post-emergent, Foliar Spray; 1 Application at 0.7 lbs ai/A)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Surrogate Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 10.5 - 168 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.10 - 1.6<br>0.071 - 1.1<br>0.016 - 0.26 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 10.5 - 95 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.10 - 0.93<br>0.071 - 0.65<br>0.016 - 0.15 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 10.5 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.023<br>0.016<br>0.003 |
| Mammalian Subacute Dietary $LC_{50}$ | 10.5 - 168 ppm | 1330 ppm | 0.008 - 0.13 |
| Mammalian Reproduction NOEL | 10.5 - 168 ppm | 10 ppm | 1.1 - 17 |
| Avian Subacute Dietary $LC_{50}$ | 10.5 - 168 ppm | 136 ppm | 0.077 - 1.2 |
| Avian Reproduction NOEL | 10.5 - 168 ppm | 25 ppm | 0.42 - 6.7 |
| Freshwater Fish Acute $LC_{50}$ | 3.56 ppb | 1.8 ppb | 2.0 |
| Fish Reproduction NOEC | 1.7 - 3.14 ppb | 0.57 ppb | 3.0 - 5.5 |
| Aquatic Invertebrate Acute $LC_{50}$ | 3.56 ppb | 0.10 ppb | 36 |
| Freshwater Invert. Reproduction NOEC | 1.7 - 3.14 ppb | 0.04 ppb | 52 - 78 |
| Estuarine Fish Acute $LC_{50}$ | 3.56 ppb | 0.96 ppb | 3.7 |
| Estuarine Fish Reproduction NOEC | 1.7 - 3.14 ppb | 0.28 ppb | 6.1 - 11 |
| Estuarine Invertebrate Acute $LC_{50}$ | 3.56 ppb | 0.035 ppb | 100 |

| | | | |
|---|---|---|---|
| Estuarine Invert. Reproduction NOEC | 1.7 - 3.14 ppb | < 0.0046 ppb | > 370 > 680 |

**Risk Summary for a Typical Aerial, Alfalfa Use**: Risk quotients derived for a single foliar application at the typical use rate on alfalfa exceed the levels of concern for most non-target aquatic and terrestrial animals. The range of RQs for an average application rate is as follows: mammalian acute (0.003-1.6) and reproduction (1.1-17), avian acute (0.08-1.2) and reproduction (0.42-6.7), freshwater fish acute (2.0) and reproduction (3.0-5.5), freshwater invertebrates acute (36) and reproduction (52-78), estuarine fish acute (3.7) and reproduction (6.1-11), and estuarine invertebrates acute (100) and reproduction (> 370 > 680). About 10 percent of the alfalfa crop is treated a second time which may increase the above risk quotients depending on the time interval between treatments.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 6.6 ppm and whole fish of 4.6 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Dow has indicated that the typical chlorpyrifos use on alfalfa is a foliar aerial application at 1.5 pt of Lorsban 4E per acre (0.75 lbs ai./A). Dow's typical use rate on alfalfa is slightly higher than the 0.7 lbs ai./A cited by BEAD (1999). Dow's typical use rate is accurate the risks are about 7 percent higher than estimated above.

**Clover Grown for Seed Use**: Clover acreage treated with chlorpyrifos, the total amount used on clover, and typical use rates have not been identified. Chlorpyrifos is sprayed by ground equipment on clover grown for seed before planting and at the foliar stage, once each at rates of 2 lbs ai/A. The interval between treatments is assumed to be 14 days. The integrated terrestrial EECs for the two applications are estimated with the FATE model for accumulated residues. Aquatic EECs are estimated using the GENEEC model, which is likely to overestimate runoff and risks for this cover crop. Risks to fish and wildlife are assessed for clover grown for seed in the table below.
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**Risk Quotients for Clover Grown for Seed**
**(Preplant and foliar, Ground Spray; 1 Application each at 2.0 lbs ai/A; Interval Unknown, Assumed 14 Days)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams) | 338 - 600 ppm | 102 ppm | 3.3 - 5.9 |
| (35 grams) | | 147 ppm | 2.3 - 4.1 |
| (1000 grams) | | 647 ppm | 0.52 - 0.93 |
| Mammalian Insectivores $LD_{50}$ (15 grams) | 38 - 338 ppm | 102 ppm | 0.37 - 5.9 |
| (35 grams) | | 147 ppm | 0.26 - 4.1 |
| (1000 grams) | | 647 ppm | 0.059- 0.52 |

| | | | |
|---|---|---|---|
| Mammalian Granivores $LD_{50}$ (15 grams)<br>(35 grams)<br>(1000 grams) | 38 - 338 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.082- 0.73<br>0.059- 0.52<br>0.012- 0.10 |
| Mammalian Subacute Dietary $LC_{50}$ | 338 - 600 ppm | 1330 ppm | 0.25 - 0.45 |
| Mammalian Reproduction NOEL | 338 - 600 ppm | 10 ppm | 34 - 60 |
| Avian Subacute Dietary $LC_{50}$ | 338 - 600 ppm | 136 ppm | 2.5 - 4.4 |
| Avian Reproduction NOEL | 338 - 600 ppm | 25 ppm | 14 - 24 |
| Freshwater Fish Acute $LC_{50}$ | 15 ppb | 1.8 ppb | 8.3 |
| Fish Reproduction NOEC | 7.25- 13 ppb | 0.57 ppb | 13 - 23 |
| Aquatic Invertebrate Acute $LC_{50}$ | 15 ppb | 0.10 ppb | 150 |
| Freshwater Invert. Reproduction NOEC | 7.25- 13 ppb | 0.04 ppb | 180 - 320 |
| Estuarine Fish Acute $LC_{50}$ | 15 ppb | 0.96 ppb | 16 |
| Estuarine Fish Reproduction NOEC | 7.25- 13 ppb | 0.28 ppb | 26 - 46 |
| Estuarine Invertebrate Acute $LC_{50}$ | 15 ppb | 0.035 ppb | 430 |
| Estuarine Invert. Reproduction NOEC | 7.25- 13 ppb | < 0.0046 ppb | >1600 > 2800 |

**Risk Summary for Maximum Clover Uses**: Risk quotients for chlorpyrifos sprayed to clover as pre-plant and foliar applications at 2 lbs ai/A each exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are acute $LD_{50}$s for small mammals (0.012 to 5.9), acute $LC_{50}$s for birds (2.5-4.4), acute fish $LC_{50}$s (8.3-16) and aquatic invertebrate acute $LC_{50}$s (150-430), and chronic NOECs for small mammals (34-60), bird NOECs (14-24), fish NOECs (13-23), aquatic invertebrate NOECs (>180 > 2800). The acute $LC_{50}$ values for both fish and aquatic invertebrate species are exceeded by EECs for more than 56 days following two applications on alfalfa.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 28 ppm and whole fish of 20 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Grass Grown of Seed Use**: Less than 1 percent of the total chlorpyrifos poundage used on agricultural crops. Acreage treated with chlorpyrifos and typical use rates have not been identified for grass growth for seed. Chlorpyrifos is aerially sprayed on grass three times per season at 1 lb ai/A each. Since the labels do not specify the minimal interval between treatments, it is assumed to be 7 days (the default value). Accumulation of terrestrial residues were estimated with the FATE Model. The GENEEC model is likely to overestimate EECs and aquatic risks for this cover crop, because the model assumes runoff from bare ground. Grass would be expected to reduce runoff. Risks to fish and wildlife are assessed for grass grown for seed in the table below.

| Risk Quotients for Grass Grown for Seed<br>(Foliar, Aerial Spray; 3 Application each at 1.0 lb ai/A; Interval Unknown, Assumed 7 Days)<br>(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 236 - 420 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.3 - 4.1<br>1.6 - 2.9<br>0.36 - 0.65 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 26 - 236 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.25 - 2.3<br>0.18 - 1.6<br>0.040- 0.36 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 26 - 236 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.056- 0.91<br>0.040- 0.65<br>0.008- 0.13 |
| Mammalian Subacute Dietary $LC_{50}$ | 236 - 420 ppm | 1330 ppm | 0.18 - 0.32 |
| Mammalian Reproduction NOEL | 236 - 420 ppm | 10 ppm | 24 - 42 |
| Avian Subacute Dietary $LC_{50}$ | 236 - 420 ppm | 136 ppm | 1.7 - 3.1 |
| Avian Reproduction NOEL | 236 - 420 ppm | 25 ppm | 9.4 - 17 |
| Freshwater Fish Acute $LC_{50}$ | 17 ppb | 1.8 ppb | 9.4 |
| Fish Reproduction NOEC | 8.0 - 15 ppb | 0.57 ppb | 14 - 26 |
| Aquatic Invertebrate Acute $LC_{50}$ | 17 ppb | 0.10 ppb | 170 |
| Freshwater Invert. Reproduction NOEC | 8.0 - 15 ppb | 0.04 ppb | 200 - 380 |
| Estuarine Fish Acute $LC_{50}$ | 17 ppb | 0.96 ppb | 18 |
| Estuarine Fish Reproduction NOEC | 8.0 - 15 ppb | 0.28 ppb | 29 - 54 |
| Estuarine Invertebrate Acute $LC_{50}$ | 17 ppb | 0.035 ppb | 490 |
| Estuarine Invert. Reproduction NOEC | 8.0 - 15 ppb | < 0.0046 ppb | >1700 > 3300 |

**Risk Summary for Maximum Grass grown for Seed**: Risk quotients for chlorpyrifos aerially applied to grass grown for seed exceed the levels of concern for most non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.008-4.1), subacute (0.18-0.32), and reproduction (24-42), avian subacute (1.7-3.1) and chronic (9.4-17), fish acute (9.4-18) and chronic (14-54), aquatic invertebrate acute (170-490) and chronic (> 200 > 3300).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 31 ppm and whole fish of 22 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Mint Uses**: Mint acreage treated with chlorpyrifos, the total poundage used, and the typical use rates have not been identified. Chlorpyrifos is sprayed by ground equipment before planting (soil

incorporated) and at the foliar stage, once each at rates of 2 lbs ai/A. Risks to fish and wildlife from one foliar application at 2 lbs ai/A are summarized in the table below.

**Risk Quotients for Mint**
**(Foliar, Ground Spray; 1 Application at 2.0 lbs ai/A)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams) | 270 - 480 ppm | 102 ppm | 2.6 - 4.7 |
| (35 grams) | | 147 ppm | 1.8 - 3.3 |
| (1000 grams) | | 647 ppm | 0.42 - 0.74 |
| Mammalian Insectivores $LD_{50}$ (15 grams) | 30 - 270 ppm | 102 ppm | 0.29 - 2.6 |
| (35 grams) | | 147 ppm | 0.20 - 1.8 |
| (1000 grams) | | 647 ppm | 0.046- 0.42 |
| Mammalian Granivores $LD_{50}$ (15 grams) | 30 - 270 ppm | 462 ppm | 0.065- 0.58 |
| (35 grams) | | 647 ppm | 0.046- 0.42 |
| (1000 grams) | | 3233 ppm | 0.009- 0.084 |
| Mammalian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 1330 ppm | 0.023- 0.36 |
| Mammalian Reproduction NOEL | 30 - 480 ppm | 10 ppm | 3.0 - 48 |
| Avian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 136 ppm | 0.22- 3.5 |
| Avian Reproduction NOEL | 30 - 480 ppm | 25 ppm | 1.2 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 7.4 ppb | 1.8 ppb | 4.1 |
| Fish Reproduction NOEC | 3.72- 6.46 ppb | 0.57 ppb | 6.5 - 11 |
| Aquatic Invertebrate Acute $LC_{50}$ | 7.4 ppb | 0.10 ppb | 74 |
| Freshwater Invert. Reproduction NOEC | 3.72- 6.46 ppb | 0.04 ppb | 93 - 160 |
| Estuarine Fish Acute $LC_{50}$ | 7.4 ppb | 0.96 ppb | 7.7 |
| Estuarine Fish Reproduction NOEC | 3.72- 6.46 ppb | 0.28 ppb | 13 - 23 |
| Estuarine Invertebrate Acute $LC_{50}$ | 7.4 ppb | 0.035 ppb | 210 |
| Estuarine Invert. Reproduction NOEC | 3.72- 6.46 ppb | < 0.0046 ppb | > 810 > 1400 |

**Risk Summary for Maximum Mint Uses**: Risk quotients for chlorpyrifos sprayed on mint as a foliar application at 2 lbs ai/A exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are acute $LD_{50}$s for small mammals (0.009 to 4.7), acute $LC_{50}$s for birds (0.22-3.5), acute fish $LC_{50}$s (4.1-7.7) and aquatic invertebrate acute $LC_{50}$s (74-210), and chronic NOAECs for small mammals (3.0-48), bird NOAECs (1.2-19), fish NOAECs (13-160), aquatic invertebrate NOAECs (93 > 1400).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 15 ppm and whole fish of 10 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Wheat Uses**: Although chlorpyrifos is currently applied to only about 1 percent (likely maximum of 1 percent treated) of the approximately 43,000,000 acres of winter wheat fields in the U.S. The leading states using about 84% of the chlorpyrifos applied to wheat in decreasing order are Texas, Colorado, Kansas, Wyoming, Montana, and New Mexico.

Wildlife utilization of wheat fields is relatively high compared to many other crops. Wildlife which feed in wheat fields include quail, pheasant, grouse, partridge, prairie chicken, wild turkey, pigeons, doves, songbirds, cranes, ducks, geese, rabbit, deer, and antelope to a low to high degree. While it is unlikely that deer or antelope might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated wheat fields. Bobwhite quail, pheasant, wild turkeys, songbirds, ducks, cranes, and rabbits also nest and brood young in wheat fields. Wheat fields have been identified as important feeding areas for migratory species in the flyways.

Maximum Wheat Use: Chlorpyrifos use on winter wheat can be sprayed twice per season at 0.5 lb ai/A with ground, sprinkler, or aerial equipment. The interval between applications is assumed to be 7 days. Risks to fish and wildlife are assessed for wheat uses in the table below.

**Risk Quotients for Wheat**
**(Foliar, Aerial Spray; 2 Applications at 0.5 lbs ai/A; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 102 - 180 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.0 - 1.8<br>0.69 - 1.2<br>0.16 - 0.28 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 13 - 102 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.13 - 1.0<br>0.088- 0.69<br>0.020- 0.16 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 13 - 102 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.028- 0.22<br>0.020- 0.16<br>0.004- 0.032 |
| Mammalian Subacute Dietary $LC_{50}$ | 13 - 180 ppm | 1330 ppm | 0.010- 0.14 |
| Mammalian Reproduction NOEL | 13 - 180 ppm | 10 ppm | 1.3 - 18 |
| Avian Subacute Dietary $LC_{50}$ | 13 - 180 ppm | 136 ppm | 0.096- 1.3 |
| Avian Reproduction NOEL | 13 - 180 ppm | 25 ppm | 0.52 - 7.2 |
| Freshwater Fish Acute $LC_{50}$ | 5.5 ppb | 1.8 ppb | 3.1 |
| Fish Reproduction NOEC | 2.6 - 4.9 ppb | 0.57 ppb | 4.6 - 8.6 |
| Aquatic Invertebrate Acute $LC_{50}$ | 5.5 ppb | 0.10 ppb | 55 |
| Freshwater Invert. Reproduction NOEC | 2.6 - 4.9 ppb | 0.04 ppb | 65 - 120 |
| Estuarine Fish Acute $LC_{50}$ | 5.5 ppb | 0.96 ppb | 5.7 |

| | | | |
|---|---|---|---|
| Estuarine Fish Reproduction NOEC | 2.6 - 4.9 ppb | 0.28 ppb | 9.3 - 18 |
| Estuarine Invertebrate Acute $LC_{50}$ | 5.5 ppb | 0.035 ppb | 160 |
| Estuarine Invert. Reproduction NOEC | 2.6 - 4.9 ppb | < 0.0046 ppb | > 570 > 1100 |

**Risk Summary for Maximum Aerial, Wheat Use**: Risk quotients for chlorpyrifos use on wheat as a foliar spray application exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients for small mammals are (acute 0.005-1.8), subacute (0.01-0.14) and reproduction (1.3-18), avian subacute (0.096-1.3) and reproduction (0.52-7.2), fish acute (3.1) and reproduction (4.6-8.6), and aquatic invertebrate acute (55) and reproduction (65-120). Estuarine risk quotients for the few areas where wheat is grown near coastal areas are estuarine fish acute (5.7) and reproduction (9.3-18) and estuarine invertebrate acute (160) and reproduction (> 570 > 1100). Buffer zones are required for ground and aerial applications on wheat. The degree to which the buffer zone reduces aquatic risks is unknown. When data from the Spray Drift Task Force are finalized, the aquatic risks can be refined.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 10 ppm and whole fish of 7.1 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and equal the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Typical Wheat Use: According to BEAD, the typical average chlorpyrifos usage on spring wheat is 1 application of 0.39 lbs ai/A and on winter wheat is 1.2 foliar applications at 0.47 lbs ai/A. The risk quotients are assessed for a single typical application scenario on winter wheat in the table below.

**Risk Quotients for Typical Use on Winter Wheat**
**(Post-emergent, Aerial Foliar Spray; 1 Application at 0.47 lbs ai/A)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Surrogate Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 63 - 113 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.62 - 1.1<br>0.43 - 0.77<br>0.097 - 0.17 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 7 - 63 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.069 - 0.62<br>0.048 - 0.43<br>0.011 - 0.097 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 7 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.015<br>0.011<br>0.002 |
| Mammalian Subacute Dietary $LC_{50}$ | 7 - 113 ppm | 1330 ppm | 0.005 - 0.085 |
| Mammalian Reproduction NOEL | 7 - 113 ppm | 10 ppm | 0.70 - 11 |
| Avian Subacute Dietary $LC_{50}$ | 7 - 113 ppm | 136 ppm | 0.051 - 0.83 |

| | | | |
|---|---|---|---|
| Avian Reproduction NOEL | 7 - 113 ppm | 25 ppm | 0.28 - 4.5 |
| Freshwater Fish Acute $LC_{50}$ | 2.4 ppb | 1.8 ppb | 1.3 |
| Fish Reproduction NOEC | 1.13 - 2.12 ppb | 0.57 ppb | 2.0 - 3.7 |
| Aquatic Invertebrate Acute $LC_{50}$ | 2.4 ppb | 0.10 ppb | 24 |
| Freshwater Invert. Reproduction NOEC | 1.13 - 2.12 ppb | 0.04 ppb | 28 - 53 |
| Estuarine Fish Acute $LC_{50}$ | 2.4 ppb | 0.96 ppb | 2.5 |
| Estuarine Fish Reproduction NOEC | 1.13 - 2.12 ppb | 0.28 ppb | 4.0 - 7.6 |
| Estuarine Invertebrate Acute $LC_{50}$ | 2.4 ppb | 0.035 ppb | 69 |
| Estuarine Invert. Reproduction NOEC | 1.13 - 2.12 ppb | < 0.0046 ppb | > 240 > 460 |

**Risk Summary for a Typical Aerial, Wheat Use**: Risk quotients derived for a single application at the typical use rate on wheat exceed the levels of concern of most non-target aquatic and terrestrial animals. The range of RQs for an average application rate is as follows: mammalian acute (0.002-1.1) and reproduction (0.70-11), avian acute (0.051-0.83) and reproduction (0.28-4.5), freshwater fish acute (1.3) and reproduction (2.0-3.7), freshwater invertebrates acute (24) and reproduction (28-53), estuarine fish acute (2.5) and reproduction (4.0-7.6), and estuarine invertebrates acute (69) and reproduction (> 240 > 460). The acute $LC_{50}$ value for aquatic invertebrate species is exceeded by the EECs for about 56 days. When data from the Spray Drift Task Force are finalized, the aquatic risks can be refined.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.4 ppm and whole fish of 3.1 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

### (iii) Field Crops (Peanuts, Cotton, Sorghum, Soybeans, Sunflowers & Tobacco)

Chlorpyrifos may be applied to many field crops. Most crops in this category are major uses: peanuts (about 1.5 percent of total chlorpyrifos poundage), cotton (about 3.2%), tobacco, sorghum, soybeans and sunflowers (less than 1% each).

**Peanut Uses**: About 1.5 percent of total chlorpyrifos poundage is used on peanuts and is applied to about 10 percent (15 percent is likely maximum) of the approximately 1,600,000 acres of peanuts in the U.S.. Chlorpyrifos use on peanuts is mostly granular treatments and some minor spray applications. According to BEAD, the typical use rate on peanuts is 1.1 granular applications at an average of 1.8 lbs ai/A on approximately 160,000 to 240,000 acres. The leading states using chlorpyrifos in decreasing order of poundage are Georgia, North Carolina, Virginia and Alabama.

Wildlife utilization of peanut fields is relatively high with a fair diversity of avian and mammalian species. Wildlife reported to feed moderately to high in peanuts fields include quail, doves, songbirds, waterfowl, wild turkey, rabbits, squirrels, raccoons, opossum, and deer with a moderate to high degree of use. While it is unlikely that deer might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated cotton fields. Bobwhite quail is the only species specifically listed as nesting in peanut fields.

Peanut Spray Uses: Directions for use on registered labels allow chlorpyrifos use on peanuts as a ground spray, pre-plant at 2 lbs ai/A and soil incorporated 3 to 4 inches. Soil incorporation after a spray application, reduces the amount of treated vegetation or insects on the soil surface, but it does not alter the concentration of the pesticide on the food items. Maximum seasonal application is 4 lbs ai/A for all uses. The following table shows the risk quotients fish and wildlife for sprayed peanut fields.

**Risk Quotients for Peanuts**
**(Pre-plant Spray; 1 Application at 2 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 480 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 4.7<br>0.20 - 3.3<br>0.046- 0.74 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046- 0.42 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065<br>0.046<br>0.0093 |
| Mammalian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 1330 ppm | 0.023- 0.36 |

| | | | |
|---|---|---|---|
| Mammalian Reproduction NOEL | 30 - 480 ppm | 10 ppm | 3 - 48 |
| Avian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 136 ppm | 0.22 - 3.5 |
| Avian Reproduction NOEL | 30 - 480 ppm | 25 ppm | 1.2 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 2.44 ppb | 1.8 ppb | 1.4 |
| Fish Reproduction NOEC | 1.23 - 2.17 ppb | 0.57 ppb | 2.2 - 3.8 |
| Aquatic Invertebrate Acute $LC_{50}$ | 2.44 ppb | 0.10 ppb | 24 |
| Freshwater Invert. Reproduction NOEC | 1.23 - 2.17 ppb | 0.04 ppb | 31 - 54 |
| Estuarine Fish Acute $LC_{50}$ | 2.44 ppb | 0.96 ppb | 2.5 |
| Estuarine Fish Reproduction NOEC | 1.23 - 2.17 ppb | 0.28 ppb | 4.4 - 7.8 |
| Estuarine Invertebrate Acute $LC_{50}$ | 2.44 ppb | 0.035 ppb | 70 |
| Estuarine Invert. Reproduction NOEC | 1.23 - 2.17 ppb | < 0.0046 ppb | > 270 > 470 |

**Risk Summary for Maximum Peanut Spray Uses**: A pre-plant spray treatment of chlorpyrifos to peanuts yields risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients for the spray use are mammalian acute (0.009-4.7), subacute dietary (0.023-0.36) and reproduction NOEL (3-48); avian dietary (0.22-3.5) and reproduction NOEL (1.2-19), freshwater fish acute (1.4) and reproduction (2.2-3.8), aquatic invertebrate acute (24) and reproduction (31-54), estuarine fish acute (2.5) and reproduction (4.4-7.8), estuarine invertebrate acute (70) and reproduction (>270->470).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.8 ppm and whole fish of 3.3 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Peanut Granular Uses: Directions for use on registered labels allow chlorpyrifos use on peanuts as a granular application in a 6 to 12-inch band, as a ground application with soil incorporation at planting at 1.13-2.25 oz. ai/1000 ft and applied again at postplant, if applied earlier at 1.13 oz. ai/1000 ft. Granules are banded at early pegging at 2.25 oz. ai/1000 ft or applied as an aerial broadcast prior to or at pegging at 1.95 lb ai/A. The time interval between the two applications is not specified on the label, hence the typical period of 40 days used in Georgia is used. Since the first application is soil incorporated, separate risk scenarios are used for the terrestrial and aquatic habitats. Accumulation of granules from the first application following the second treatment is considered minor and has been ignored. The terrestrial EECs for wildlife are higher occurs from the early peg, granular application. Aquatic areas get input from both applications. Maximum seasonal application is 4 lbs ai/A for all uses. The following tables show the risk quotients for granular uses on peanuts and the additive risks from the pre-plant spray and post-plant granular applications.

| Granular Risk Quotients for Peanuts<br>(6-Inch Band at Plant, 1 Application at 2.25 oz. ai/1000 ft; 4-inch Soil Incorporation)<br>(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model**) | | | | |
|---|---|---|---|---|
| **Species** | **Toxicity** | **Exposure** | **Toxicity Dose** | **Risk Quotient** |
| Mammalian $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 19 $mg/ft^{2}$* | 1.5 mg<br>3.4 mg<br>97 mg | 13<br>5.6<br>0.20 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 19 $mg/ft^{2}$* | 0.28 mg | 68 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 2.49 ppb | | 1.4 |
| Fish Reproduction NOEC | 0.57 ppb | 1.26- 2.17 ppb | | 2.2 - 3.8 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 2.49 ppb | | 25 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.26- 2.17 ppb | | 32 - 54 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 2.49 ppb | | 2.6 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.26- 2.17 ppb | | 4.5 - 7.8 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 2.49 ppb | | 71 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.26- 2.17 ppb | | >270 > 470 |

* $mg\ ai/ft^2 = \frac{(2.25\ oz\ ai/1000\ ft\ row) \times 28{,}349\ mg/oz. \times 15\ \%\ exposed}{1{,}000\ feet\ row \times band\ width\ (0.5\ ft.)} = 19\ mg\ ai./ft.^2$

** $lbs\ ai/A = \frac{2.25\ (oz.\ ai./1000\ feet\ of\ row) \times 43560\ ft^2/A}{16\ oz./lb \times 1000\ ft \times 2.0\ row\ spacing\ (ft.)} = 3\ lbs/A$

**Risk Summary for Maximum At-Plant Peanut Granular Uses**: An at-plant granular application of chlorpyrifos to peanuts yields risk quotients which exceed the levels of concern for all non-target aquatic and terrestrial animal groupings. Risk quotients for the at-plant granular use are mammalian acute (0.20-13), avian acute (68), freshwater fish acute (1.4) and reproduction (2.2-3.8), aquatic invertebrate acute (25) and reproduction (32-54), estuarine fish acute (2.6) and reproduction (4.5-7.8), estuarine invertebrate acute (71) and reproduction (>270->470).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.9 ppm and whole fish of 3.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

| Granular Risk Quotients for Peanuts<br>(Aerial Broadcast prior to or at Early Pegging, 1 Application at 1.95 lbs ai/A)<br>(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model) | | | | |
|---|---|---|---|---|
| **Species** | **Toxicity** | **Exposure** | **Toxicity Dose** | **Risk Quotient** |

| | | | | |
|---|---|---|---|---|
| Mammalian $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 20 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 13<br>5.9<br>0.21 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 20 mg/ft$^2$* | 0.28 mg | 71 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 1.66 ppb | | 0.92 |
| Fish Reproduction NOEC | 0.57 ppb | 0.84-1.45 ppb | | 1.5 - 2.5 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 1.66 ppb | | 17 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 0.84-1.45 ppb | | 21 - 36 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 1.66 ppb | | 1.7 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 0.84-1.45 ppb | | 3 - 5.1 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 1.66 ppb | | 47 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 0.84-1.45 ppb | | > 180 >320 |

* mg ai/foot$^2$ = $\frac{1.95 \text{ lb ai/A X } 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2}$ = 20 mg/ft$^2$

**Risk Summary for Maximum Broadcast Peanut Granular Uses at Early Pegging**: A broadcast granular application of chlorpyrifos to peanuts at early pegging yields risk quotients which exceed the levels of concern for all non-target aquatic and terrestrial animal groupings. Risk quotients for the at-plant granular use are mammalian acute (0.21-13), avian acute (71), freshwater fish acute (0.92) and reproduction (1.5-2.5), aquatic invertebrate acute (17) and reproduction (21-36), estuarine fish acute (1.7) and reproduction (3.0-5.1), estuarine invertebrate acute (47) and reproduction (>180->320).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 3.3 ppm and whole fish of 2.3 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Combined Risks for Multiple Peanut Uses**: Combined risks for multiple applications for spray and granular applications should be assessed to determine the full extent of exposures for non-target aquatic and terrestrial animals. However at present, no methodology exists to combine terrestrial risk assessments for spray and granular applications (i.e., EECs expressed in ppm or ppb can not be added to mg/sq$^2$ foot). Consequently, only aquatic risks are assessed for the combination of the two peanut applications (pre-plant and at-pegging) and are summarized in the table below.

**Aquatic Risk Quotients for Peanuts**
**(Pre-plant Spray (4" Soil Incorporation) and at Early Peg Granular Application (Aerial Broadcast); 2 Applications at 2 lbs ai/A**
**(Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Freshwater Fish Acute $LC_{50}$ | 15.4 ppb | 1.8 ppb | 8.6 |
| Fish Reproduction NOEC | 6.0 - 11.5 ppb | 0.57 ppb | 11 - 20 |
| Aquatic Invertebrate Acute $LC_{50}$ | 15.4 ppb | 0.10 ppb | 150 |
| Freshwater Invert. Reproduction NOEC | 6.0 - 11.5 ppb | 0.04 ppb | 150 - 290 |
| Estuarine Fish Acute $LC_{50}$ | 15.4 ppb | 0.96 ppb | 16 |
| Estuarine Fish Reproduction NOEC | 6.0 - 11.5 ppb | 0.28 ppb | 21 - 41 |
| Estuarine Invertebrate Acute $LC_{50}$ | 15.4 ppb | 0.035 ppb | 440 |
| Estuarine Invert. Reproduction NOEC | 6.0 - 11.5 ppb | < 0.0046 ppb | >1300 > 2500 |

**Risk Summary for Accumulation of Maximum Spray and Granular Peanut Uses**: Accumulation of residues in the aquatic environment from a pre-plant and an early pegging applications (maximum of 4 lbs ai/A per year) at a 40-day interval period yields risk quotients which exceed the levels of concern for all non-target aquatic groupings, except estuarine algae. Aquatic risk quotients for the two combined applications are as follows: freshwater fish acute (8.6) and reproduction (11-20), aquatic invertebrate acute (150) and reproduction (150-290), estuarine fish acute (16) and reproduction (21-41), estuarine invertebrate acute (440) and reproduction (>1300->2500).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 23 ppm and whole fish of 16 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Typical Peanut Use: According to BEAD, the typical use rate on peanuts is 1.1 applications at an average of 1.8 lbs ai/A. According to Dow response (1999) the typical application is a granular, band application at 2.25 oz. ai/1000 feet of row at the early pegging growth stage. In the table below, the risk quotients are assessed for a typical use scenario.

**Granular Risk Quotients for Typical Use on Peanuts**
**(6-Inch Band at Plant, 1 Application at 2.25 oz. ai/1000 ft; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model**)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 19 $mg/ft^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 13<br>5.6<br>0.20 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 19 $mg/ft^2$* | 0.28 mg | 68 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 2.49 ppb | | 1.4 |

| | | | | |
|---|---|---|---|---|
| Fish Reproduction NOEC | 0.57 ppb | 1.26- 2.17 ppb | | 2.2 - 3.8 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 2.49 ppb | | 25 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.26- 2.17 ppb | | 32 - 54 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 2.49 ppb | | 2.6 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.26- 2.17 ppb | | 4.5 - 7.8 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 2.49 ppb | | 71 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.26- 2.17 ppb | | >270 > 470 |

* mg ai/$ft^2$ = $\frac{(2.25 \text{ oz ai/1000 ft row}) \times 28{,}349 \text{ mg/oz.} \times 15 \% \text{ exposed}}{1{,}000 \text{ feet row} \times \text{band width (0.5 ft.)}}$ = 19 mg ai./$ft.^2$

** lbs ai/A = $\frac{2.25 \text{ (oz. ai./1000 feet of row)} \times 43560 \text{ } ft^2/A}{16 \text{ oz./lb} \times 1000 \text{ ft} \times 2.0 \text{ row spacing (ft.)}}$ = 3 lbs/A

**Risk Summary for Typical Peanut Granular Use at the Early Pegging Stage**: The typical application of chlorpyrifos on peanuts is a granular treatment at early pegging growth stage and yields risk quotients which exceed the levels of concern for all non-target aquatic and terrestrial animal groupings. Risk quotients for the pegging stage, granular use are mammalian acute (0.20-13), avian acute (68), freshwater fish acute (1.4) and reproduction (2.2-3.8), aquatic invertebrate acute (25) and reproduction (32-54), estuarine fish acute (2.6) and reproduction (4.5-7.8), estuarine invertebrate acute (71) and reproduction (>270->470).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.9 ppm and whole fish of 3.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Cotton Uses**: Chlorpyrifos use on cotton includes a seed slurry treatment, a gin trash treatment, and up to six foliar broadcast spray applications. Discussion of risks posed by seed treatments are addressed at the beginning of the corn section. The use rate on cotton seed is 2 oz. ai/ 100 lbs of seed which is twice the uses rate of corn and other seed treatments. Therefore the risks are twice that of corn seed and the number of seeds equivalent to the $LD_{50}$ is half the number for corn. Chlorpyrifos use on gin trash has not been assessed for eco-risks. The major chlorpyrifos use on cotton is six foliar spray applications per season. According to BEAD, about 3.2 percent of the total chlorpyrifos use is applied to about 5 percent (likely maximum of 6 percent) of the approximately 12,400,000 acres of cotton in the U.S. The typical average chlorpyrifos usage on cotton is 1.7 applications at 0.6 lbs ai/A on approximately 640,000 to 800,000 acres. The leading states using about 84 percent of the chlorpyrifos applied to cotton in decreasing order of poundage are Arizona, Mississippi, and California, Texas, and Louisiana.

Wildlife utilization of cotton fields is low to moderate. Wildlife that feed in cotton fields include quail, pheasant, doves, songbirds, rabbits, raccoon, and deer with a low to high degree of use.

While it is unlikely that deer might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated cotton fields. Bobwhite quail, pheasant (brood-rearing), and rabbits also nest and brood young in cotton fields. The following tables estimate the risks quotients for chlorpyrifos applications on cotton.

The major chlorpyrifos use on cotton is six spray applications per season by ground, aerial or sprinkler irrigation equipment primarily as a broadcast foliar spray at 0.1875 to 1 lb ai/A depending on the pest in all states. Risks have been assessed for 6 aerial applications at the maximum use rate (1 lb ai/A), and BEAD's typical rate (1.7 aerial applications at 0.6 lbs ai/A). Dow's response (1999) holds that the 3-day retreatment interval is "an extremely low probability" and that the typical use is 1 spray application at 0.75 lbs ai/A. The assessment remains

Multiple Aerial Foliar Spray Applications on Cotton: Assessment of risks for six foliar applications at the maximum use rate (1 lb ai/A) on cotton are presented in the following table.

**Risk Quotients for Cotton**
**(Postplant Foliar Spray; 1 lb ai/A; 6 Applications; 3-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 48.5- 777 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.48 - 7.6<br>0.33 - 5.3<br>0.075- 1.2 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 48.5- 437 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.48 - 4.3<br>0.33 - 3.0<br>0.075- 0.68 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 48.5 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.10<br>0.075<br>0.015 |
| Mammalian Subacute Dietary $LC_{50}$ | 48.5- 777 ppm | 1330 ppm | 0.036- 0.58 |
| Mammalian Reproduction NOEL | 48.5- 777 ppm | 10 ppm | 4.9 - 78 |
| Avian Subacute Dietary $LC_{50}$ | 48.5- 777 ppm | 136 ppm | 0.36- 5.7 |
| Avian Reproduction NOEL | 48.5- 777 ppm | 25 ppm | 1.9 - 31 |
| Freshwater Fish Acute $LC_{50}$ | 14 ppb | 1.8 ppb | 7.8 |
| Fish Reproduction NOEC | 5.7- 10.8 ppb | 0.57 ppb | 10 - 19 |
| Aquatic Invertebrate Acute $LC_{50}$ | 14 ppb | 0.10 ppb | 140 |
| Freshwater Invert. Reproduction NOEC | 5.7- 10.8 ppb | 0.04 ppb | 140 - 270 |
| Estuarine Fish Acute $LC_{50}$ | 14 ppb | 0.96 ppb | 15 |
| Estuarine Fish Reproduction NOEC | 5.7- 10.8 ppb | 0.28 ppb | 20 - 39 |
| Estuarine Invertebrate Acute $LC_{50}$ | 14 ppb | 0.035 ppb | 400 |

| | | | |
|---|---|---|---|
| Estuarine Invert. Reproduction NOEC | 5.7- 10.8 ppb | < 0.0046 ppb | >1200 > 2300 |

**Risk Summary for Maximum Use Rates and Six Applications on Cotton:** The maximum chlorpyrifos use rate on cotton is six aerial, foliar spray treatments which yields risk quotients that exceed levels of concern for species in most non-target aquatic and terrestrial animals. Risk quotients for the six spray applications are mammalian acute (0.015-7.6), subacute dietary (0.036-0.58), and reproduction NOEL (4.9-78), avian subacute dietary (0.36-5.7) and reproduction NOEL (1.9-3.1), freshwater fish acute (7.8) and reproduction (10-19), aquatic invertebrate acute (140) and reproduction (140-270), estuarine fish acute (15) and reproduction (20-39), estuarine invertebrate acute (400) and reproduction (>1200->2300). Other geographically limited, cotton uses pose less risk, but the risk quotients still exceed levels of concern for non-target aquatic and terrestrial animals.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 22 ppm and whole fish of 16 ppm. These levels are less than the mammalian subacute LC50 value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute LC50 value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Typical Cotton Use: According to BEAD, the typical average chlorpyrifos usage on cotton is 1.7 applications at about 0.6 lbs ai/A. In the table below, the risk quotients are assessed for a single typical application scenario. For about 70 percent of the chlorpyrifos-treated cotton receives a second application which yields higher risk quotients than for the single application.

**Risk Quotients for Typical Use on Cotton (Mississippi)**
**(Post-emergent, Foliar Spray; 1 Application at 0.6 lbs ai/A)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Surrogate Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 7.5 - 120 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.074 - 1.2<br>0.051 - 0.82<br>0.012 - 0.19 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 7.5 - 67.5 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.074 - 0.66<br>0.051 - 0.46<br>0.012 - 0.10 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 7.5 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.016<br>0.012<br>0.002 |
| Mammalian Subacute Dietary $LC_{50}$ | 7.5 - 120 ppm | 1330 ppm | 0.007 - 0.09 |
| Mammalian Reproduction NOEL | 7.5 - 120 ppm | 10 ppm | 0.75 - 12 |
| Avian Subacute Dietary $LC_{50}$ | 7.5 - 120 ppm | 136 ppm | 0.007 - 0.88 |
| Avian Reproduction NOEL | 7.5 - 120 ppm | 25 ppm | 0.30 - 4.8 |
| Freshwater Fish Acute $LC_{50}$ | 1.4 ppb | 1.8 ppb | 0.77 |

| | | | |
|---|---|---|---|
| Fish Reproduction NOEC | 0.6 - 1.1 ppb | 0.57 ppb | 1.1 - 1.9 |
| Aquatic Invertebrate Acute $LC_{50}$ | 1.4 ppb | 0.10 ppb | 14 |
| Freshwater Invert. Reproduction NOEC | 0.6 - 1.1 ppb | 0.04 ppb | 15 - 28 |
| Estuarine Fish Acute $LC_{50}$ | 1.4 ppb | 0.96 ppb | 1.5 |
| Estuarine Fish Reproduction NOEC | 0.6 - 1.1 ppb | 0.28 ppb | 2.1 - 3.9 |
| Estuarine Invertebrate Acute $LC_{50}$ | 1.4 ppb | 0.035 ppb | 40 |
| Estuarine Invert. Reproduction NOEC | 0.6 - 1.1 ppb | < 0.0046 ppb | > 130 > 240 |

**Risk Summary for the Typical Cotton Use:** Risk quotients modelled for 1 spray application on Mississippi cotton at the typical use rate exceed the levels of concern for most non-target aquatic and terrestrial animals. The risk quotients for a typical application is as follows: mammalian acute (0.002-1.2) and reproduction (0.75-12), avian acute (0.007-0.88) and reproduction (0.30-4.8), freshwater fish acute (0.77) and reproduction (1.1-1.9), freshwater invertebrates acute (14) and reproduction (15-28), estuarine fish acute (1.5) and reproduction (2.1-3.9), and estuarine invertebrates acute (40) and reproduction (>130->240). Risks are higher for 70 percent of the chlorpyrifos-treated cotton which typically receives a second application.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 2.3 ppm and whole fish of 1.6 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

In about 70 percent of the cases, cotton is treated with a second application which yields RQs that are even higher than the above risk values.

**Tobacco Uses**: Chlorpyrifos use on tobacco represents less than 1 percent of the total poundage of chlorpyrifos. Chlorpyrifos is applied to about 11 percent (likely maximum of 14 percent treated) of the approximately 700,000 acres of tobacco in the U.S. According to BEAD, the typical chlorpyrifos usage on tobacco is 1 application at 2.0 lbs ai/A on approximately 73,000 to 96,000 acres. The leading states using 81 percent of the chlorpyrifos applied to tobacco are North Carolina, South Carolina, Virginia, and Georgia.

Wildlife utilization of tobacco is moderate. Wildlife that feed in tobacco fields include quail, doves, songbirds, rabbits and deer. While it is unlikely that deer might be adversely affected, because of their large size, the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated tobacco fields. Bobwhite quail and rabbits brood young in tobacco fields.

Directions for tobacco use on registered labels are limited to chlorpyrifos applications as a single, pre-transplant, soil-incorporated treatment with ground equipment. The major chlorpyrifos

formulation used on tobacco is a spray treatment. Granules are applied prior to transplant. Granular pre-transplant treatments with soil incorporation are applied at 2-3 lbs ai/A by ground equipment. The spray treatments at 5 lbs ai/A are limited to North Carolina, South Carolina, and Virginia. Chlorpyrifos is sprayed at 2 lbs ai/A in a tank mix use in all tobacco growing areas. The following 2 tables estimate the risk quotients for tobacco for maximum applications as a spray and granular treatments.

**Risk Quotients for Tobacco (Limited to NC, SC, and VA Only)**
**(Pre-transplant Ground Spray, 1 Application at 5 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EECs Based on Nomograph, Aquatic EECs Based on PRZM3-EXAMS Model)**

| **Species** | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 680 -1200 ppm | 102 ppm<br>147 ppm<br>647 ppm | 6.7 - 12<br>4.6 - 8.2<br>1.1 - 1.9 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 75 - 680 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.74 - 6.6<br>0.51 - 4.6<br>0.12 - 1.1 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 75 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.16<br>0.12<br>0.023 |
| Mammalian Subacute Dietary $LC_{50}$ | 75 -1200 ppm | 1330 ppm | 0.056- 0.90 |
| Mammalian Reproduction NOEL | 75 -1200 ppm | 10 ppm | 7.5 -120 |
| Avian Subacute Dietary $LC_{50}$ | 75 -1200 ppm | 136 ppm | 0.55 - 8.8 |
| Avian Reproduction NOEL | 75 -1200 ppm | 25 ppm | 3 - 48 |
| Freshwater Fish Acute $LC_{50}$ | 40.6 ppb | 1.8 ppb | 23 |
| Fish Reproduction NOEC | 14.7 - 31 ppb | 0.57 ppb | 26 - 54 |
| Aquatic Invertebrate Acute $LC_{50}$ | 40.6 ppb | 0.10 ppb | 410 |
| Freshwater Invert. Reproduction NOEC | 14.7 - 31 ppb | 0.04 ppb | 370 - 780 |
| Estuarine Fish Acute $LC_{50}$ | 40.6 ppb | 0.96 ppb | 42 |
| Estuarine Fish Reproduction NOEC | 14.7 - 31 ppb | 0.28 ppb | 53 - 110 |
| Estuarine Invertebrate Acute $LC_{50}$ | 40.6 ppb | 0.035 ppb | 1200 |
| Estuarine Invertebrate NOEC | 14.7 - 31 ppb | < 0.0046 ppb | > 3200 >6700 |
| Estuarine Algae $EC_{50}$ | 40.6 ppb | 140 ppb | 0.29 |

**Risk Summary for Maximum Tobacco Spray Use**: One 5 lb ai/A ground spray treatment of chlorpyrifos to tobacco with soil incorporation yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The ranges of risk quotients for a single, 5 lbs ai/A application are mammalian acute (0.023-12), mammalian subacute dietary (0.056-0.90), mammalian reproduction NOEL (7.5-120), avian subacute dietary (0.55-8.8), avian reproduction NOEL (3-48), fresh water fish acute (23) and reproduction (26-54), aquatic invertebrate acute

(410) and reproduction (370-780), estuarine fish acute (42) and reproduction (53-110), estuarine invertebrate acute (1200) and reproduction (>3200->6700), and estuarine algae (0.29).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 57 ppm and whole fish of 40 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Granular Risk Quotients for Tobacco**
**(Pre-transplant, 1 Application at 3.0 lb ai/A; Soil Incorporation, Assume 4-inch)**
**(Terrestrial EEC's Based on Formula; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 4.7 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 3.1<br>1.4<br>0.048 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 4.7 mg/ft$^2$* | 0.28 mg | 17 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 10 ppb | | 5.6 |
| Fish Reproduction NOEC | 0.57 ppb | 4.9 - 8.6 ppb | | 8.6 - 15 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 10 ppb | | 100 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 4.9 - 8.6 ppb | | 120 - 220 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 10 ppb | | 10 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 4.9 - 8.6 ppb | | 18 - 31 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 10 ppb | | 280 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 4.9 - 8.6 ppb | | >1100 >1900 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 10 ppb | | 0.071 |

* mg ai/foot$^2$ = $\frac{\text{3.0 lb ai/A X 453,590 mg/lb X 15\% exp.}}{\text{43,560 ft}^2}$ = 4.7 mg/ft$^2$

**Risk Summary for Maximum Tobacco Granular Use**: Granular treatment with chlorpyrifos to pre-transplanted tobacco yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The risk quotients are mammalian acute (0.048-3.1), avian acute (17), fresh water fish acute (5.6) and reproduction (8.6-15), aquatic invertebrate acute (100) and reproduction (120-220), estuarine fish acute (10) and reproduction (18-31), estuarine invertebrate acute (280) and reproduction (>1100->1900) and estuarine algae (0.071).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 19 ppm and whole fish of 13 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels

in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Typical Tobacco Use: According to BEAD, the typical chlorpyrifos usage on tobacco is 1 application at about 2.0 lbs ai/A on approximately 76,000 to 97,000 acres. In the table below, the risk quotients are assessed for a typical, single application on tobacco at 2.0 lbs ai/A.

**Risk Quotients for Typical Use on Tobacco**
**(Pre-transplant, Ground Spray; 1 Application at 2.0 lbs ai/A; 4-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Surrogate Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 480 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 4.7<br>0.22 - 3.6<br>0.051 - 0.82 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046 - 0.42 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065<br>0.046<br>0.009 |
| Mammalian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 1330 ppm | 0.022 - 0.36 |
| Mammalian Reproduction NOEL | 30 - 480 ppm | 10 ppm | 3.0 - 48 |
| Avian Subacute Dietary $LC_{50}$ | 30 - 480 ppm | 136 ppm | 0.22 - 3.5 |
| Avian Reproduction NOEL | 30 - 480 ppm | 25 ppm | 1.2 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 2.66 ppb | 1.8 ppb | 1.5 |
| Fish Reproduction NOEC | 1.25 - 2.34 ppb | 0.57 ppb | 2.2 - 4.1 |
| Aquatic Invertebrate Acute $LC_{50}$ | 2.66 ppb | 0.10 ppb | 27 |
| Freshwater Invert. Reproduction NOEC | 1.25 - 2.34 ppb | 0.04 ppb | 31 - 59 |
| Estuarine Fish Acute $LC_{50}$ | 2.66 ppb | 0.96 ppb | 2.8 |
| Estuarine Fish Reproduction NOEC | 1.25 - 2.34 ppb | 0.28 ppb | 4.5 - 8.4 |
| Estuarine Invertebrate Acute $LC_{50}$ | 2.66 ppb | 0.035 ppb | 76 |
| Estuarine Invert. Reproduction NOEC | 1.25 - 2.34 ppb | < 0.0046 ppb | > 270 > 510 |
| Estuarine Algae $EC_{50}$ | 2.66 ppb | 140 ppb | 0.019 |

**Risk Summary for Typical Tobacco Spray Use**: Risk quotients derived for a single application at the typical use rate of 2.0 lbs ai/A on tobacco exceed the levels of concern for most non-target aquatic and terrestrial animals. The risk quotients for an average application rate is as follows: mammalian acute (0.009-4.7) and reproduction (3.0-48), avian acute (0.22-3.5) and reproduction (1.2-19), freshwater fish acute (1.5) and reproduction (2.2-4.1), freshwater invertebrates acute

(27) and reproduction (31-59), estuarine fish acute (2.8) and reproduction (4.5-8.4), and estuarine invertebrates acute (76) and reproduction (>270->510) and estuarine algae (0.019).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.9 ppm and whole fish of 3.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Sorghum Uses**: Sorghum represents less than 1 percent of total chlorpyrifos poundage. Chlorpyrifos is applied to about 2 percent (likely maximum of 3 percent treated) of the approximately 11,000,000 acres of sorghum grown in the U.S. According to BEAD, the typical chlorpyrifos usage on sorghum is 1.1 application at 0.6 lbs ai/A on approximately 210,000 to 350,000 acres. The leading states using about 76 percent of the chlorpyrifos applied to sorghum are Texas, Mississippi, Kansas, Oklahoma, Nebraska and Louisiana.

Wildlife utilization of sorghum fields for feeding is high for many mammals and birds. Species identified as feeding heavily in sorghum in one or more states include: antelope, aoudad sheep, whitetail deer, cottontail rabbits, javelina, Ord kangaroo rat, bobwhite quail, scaled quail, ring-necked pheasants, chukar partridges greater and lesser prairie chickens, wild turkeys, mourning doves, white-winged doves, mallard ducks, geese, sandhill cranes, songbirds, crows, white-necked ravens, and English sparrows. Many other avian species feed in sorghum to a lesser degree.

Directions for sorghum use on registered labels include both spray (the major use) and granular applications. Chlorpyrifos granules are applied and soil incorporated at-plant at 1.8 oz. ai/1000 feet of row; sprayed on foliage at 0.25-1 lb ai/A by ground, sprinkler irrigation, or aerial equipment; and applied as a slurry seed treatment on stored seed at 3 fl. oz. ai/cwt. The maximum seasonal spray application rate is 1.5 lbs ai/A. The following two tables show the risk quotients for maximum use rates for sorghum at-plant granular and foliar spray applications.

**Granular Risk Quotients for Sorghum**
**(At Planting, 1 Application at 1.8 oz. ai/1000 feet of row; Soil Incorporation, 2-inch)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 15.3 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 10<br>4.5<br>0.16 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 15.3 mg/ft$^2$* | 0.28 mg | 55 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 4.2 ppb | | 2.3 |
| Fish Reproduction NOEC | 0.57 ppb | 2.0 - 3.6 ppb | | 3.5 - 6.3 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 4.2 ppb | | 42 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 2.0 - 3.6 ppb | | 50 - 90 |

| | | | | |
|---|---|---|---|---|
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 4.2 ppb | | 4.4 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 2.0 - 3.6 ppb | | 7.1 - 3.8 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 4.2 ppb | | 120 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 2.0 - 3.6 ppb | | > 435 > 80 |

* mg ai/$ft^2$ = $\frac{\text{1.8 (oz ai/1000 ft row) X 28,349 mg/oz. X 15 \% exposed}}{\text{1,000 feet row X band width (0.5 ft.)}}$ = 15.3 mg ai./$ft.^2$

lbs ai/A = $\frac{\text{1.8 (oz. ai./1000 feet of row) X 43560 } ft^2/A}{\text{16 oz./lb X 1000 ft X 2.0 row spacing (ft.)}}$ = 2.5 lbs/A

**Risk Summary for Maximum Granular At-Plant Sorghum Uses**: Chlorpyrifos granules applied to sorghum in a 6-inch band at 1.8 oz. ai/1000 feet of row and soil incorporated into top 1 inch of soil yield risk quotients exceeds levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.16-10), avian acute (55), freshwater fish acute (2.3) and reproduction (3.5-6.3), aquatic invertebrate acute (42) and reproduction (50-90), estuarine fish acute (4.4) and reproduction (7.1-3.8), estuarine invertebrate acute (120) and reproduction (> 435-> 780).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 7.8 ppm and whole fish of 4.5 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Risk Quotients for Sorghum**
**(Foliar Spray; 1 lb ai/A; 1 Application)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 135 - 240 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.3 - 2.3<br>0.92 - 1.6<br>0.21 - 0.37 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 - 135 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.15 - 1.3<br>0.10 - 0.92<br>0.023- 0.21 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 - 135 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.032- 0.29<br>0.023- 0.21<br>0.005- 0.042 |
| Mammalian Subacute Dietary $LC_{50}$ | 135 - 240 ppm | 1330 ppm | 0.10 - 0.18 |
| Mammalian Reproduction NOEL | 135 - 240 ppm | 10 ppm | 14 - 24 |
| Avian Subacute Dietary $LC_{50}$ | 135 - 240 ppm | 136 ppm | 0.99 - 1.8 |
| Avian Reproduction NOEL | 135 - 240 ppm | 25 ppm | 5.4 - 9.6 |
| Freshwater Fish Acute $LC_{50}$ | 5.1 ppb | 1.8 ppb | 2.8 |

| | | | |
|---|---|---|---|
| Fish Reproduction NOEC | 2.5 - 4.5 ppb | 0.57 ppb | 4.4 - 7.9 |
| Aquatic Invertebrate Acute $LC_{50}$ | 5.1 ppb | 0.10 ppb | 51 |
| Freshwater Invert. Reproduction NOEC | 2.5 - 4.5 ppb | 0.04 ppb | 62 - 110 |
| Estuarine Fish Acute $LC_{50}$ | 5.1 ppb | 0.96 ppb | 5.3 |
| Estuarine Fish Reproduction NOEC | 2.5 - 4.5 ppb | 0.28 ppb | 8.9 - 16 |
| Estuarine Invertebrate Acute $LC_{50}$ | 5.1 ppb | 0.035 ppb | 150 |
| Estuarine Invert. Reproduction NOEC | 2.5 - 4.5 ppb | < 0.0046 ppb | > 540 > 980 |

**Risk Summary for Maximum Foliar Spray Sorghum Uses**: Aerial, foliar spray at 1 lb ai/A on sorghum poses risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.005-2.3), subacute dietary (0.10-0.18) and reproduction NOEL (14-24), avian subacute dietary (0.99-1.8), and reproduction NOEL (5.4-9.6), freshwater fish acute (2.8) and reproduction NOEC (4.4-7.9), aquatic invertebrate acute (51) and reproduction (62-110), estuarine fish acute (5.3) and reproduction (8.9-16), estuarine invertebrate acute (150) and reproduction (>540->980).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 9.8 ppm and whole fish of 6.8 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Typical Sorghum Use: Risk quotients for typical use rates for chlorpyrifos on sorghum (0.6 lbs ai/A) are about one-half of the above aerial, foliar spray values. Risk quotients for a typical spray application on sorghum exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.002-1.1), subacute dietary (0.05-0.09) and reproduction NOEL (7-12), avian subacute dietary (0.04-0.9), and reproduction NOEL (2.7-4.8), freshwater fish acute (1.4) and reproduction NOEC (2.2-3.9), aquatic invertebrate acute (25) and reproduction (31-55), estuarine fish acute (2.6) and reproduction (4.4-8), estuarine invertebrate acute (75) and reproduction (>270->490).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.9 ppm and whole fish of 3.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Soybean Uses**: According to BEAD, chlorpyrifos use on soybeans is less than 1 percent of total chlorpyrifos poundage. Chlorpyrifos is applied to less than 1 percent (likely maximum of less than 1 percent treated) of the approximately 61,000,000 acres of soybeans grown in the U.S. The typical chlorpyrifos usage on sorghum is 1 application at 0.7 lbs ai/A on approximately 90,000 to

150,000 acres (the grown stage was not specified). The leading states using about 53 percent of the chlorpyrifos applied to soybeans are Illinois, Iowa, Ohio, South Dakota, Indiana, and Nebraska.

Wildlife utilization of soybean fields for feeding is high for many mammals and birds. Species identified as feeding heavily in soybeans in one or more states include: whitetail deer, raccoon, fox squirrel, groundhog, cottontail rabbits, bobwhite quail, pheasants, greater prairie chickens, wild turkey, mourning doves, ducks, and geese.

Directions for chlorpyrifos use on soybeans on registered labels include both spray (the major use) and granular formulations. Chlorpyrifos granules are applied to soybeans and soil incorporated at-plant or postemergence at 1.2 oz. ai/1000 feet of row with ground equipment; and sprayed as a soil band at-plant or postemergence with ground equipment or sprayed on foliage at 1 lb ai/A by ground, sprinkler irrigation, or aerial equipment. The maximum seasonal, spray application rate is 3 lbs ai/A. The following 2 tables show the risk quotients for maximum application rates on soybeans.

**Granular Risk Quotients for Soybeans**
**(At Planting, 1 Application at 1.2 oz. ai/1000 feet of row; 4-inch Band; Soil Incorporation, 2-inch)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on Formula** and GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 15.5 mg/$ft^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 10<br>4.6<br>0.16 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 15.5 mg/$ft^2$* | 0.28 mg | 55 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 2.7 ppb | | 1.5 |
| Fish Reproduction NOEC | 0.57 ppb | 1.3 - 2.3 ppb | | 2.3 - 4.0 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 2.7 ppb | | 27 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.3 - 2.3 ppb | | 32 - 58 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 2.7 ppb | | 2.8 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.3 - 2.3 ppb | | 4.6 - 8.2 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 2.7 ppb | | 77 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.3 - 2.3 ppb | | > 280 > 500 |

* mg ai/$ft^2$ = $\frac{\text{1.2 (oz ai/1000 ft row) X 28,349 mg/oz. X 15 \% exposed}}{\text{1,000 feet row X band width (0.33 ft.)}}$ = 15.5 mg ai./$ft.^2$

** lbs ai/A = $\frac{\text{1.2 (oz. ai./1000 feet of row) X 43560 } ft^2/A}{\text{16 oz./lb X 1000 ft X 2.0 row spacing (ft.)}}$ = 1.6 lbs/A

| Risk Quotients for Soybeans<br>(Foliar Spray; 1 lb ai/A; 3 Applications; 14-Day Interval)<br>(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 177 - 315 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.7 - 3.1<br>1.2 - 2.1<br>0.27 - 0.50 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 20 - 177 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.17 - 1.7<br>0.14 - 1.2<br>0.031- 0.27 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 20 - 177 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.043- 0.38<br>0.031- 0.27<br>0.006- 0.055 |
| Mammalian Subacute Dietary $LC_{50}$ | 177 - 315 ppm | 1330 ppm | 0.13 - 0.24 |
| Mammalian Reproduction NOEL | 177 - 315 ppm | 10 ppm | 18 - 32 |
| Avian Subacute Dietary $LC_{50}$ | 177 - 315 ppm | 136 ppm | 1.3 - 2.3 |
| Avian Reproduction NOEL | 177 - 315 ppm | 25 ppm | 7.1 - 13 |
| Freshwater Fish Acute $LC_{50}$ | 16 ppb | 1.8 ppb | 8.9 |
| Fish Reproduction NOEC | 7.8 - 14.3 ppb | 0.57 ppb | 14 - 25 |
| Aquatic Invertebrate Acute $LC_{50}$ | 16 ppb | 0.10 ppb | 160 |
| Freshwater Invert. Reproduction NOEC | 7.8 - 14.3 ppb | 0.04 ppb | 200 - 360 |
| Estuarine Fish Acute $LC_{50}$ | 16 ppb | 0.96 ppb | 17 |
| Estuarine Fish Reproduction NOEC | 7.8 - 14.3 ppb | 0.28 ppb | 28 - 51 |
| Estuarine Invertebrate Acute $LC_{50}$ | 16 ppb | 0.035 ppb | 460 |
| Estuarine Invert. Reproduction NOEC | 7.8 - 14.3 ppb | < 0.0046 ppb | >1700 > 3100 |

**Risk Summary for Maximum Soybean Uses**: Granules applied at plant on soybeans at 1.2 oz. ai/1000 ft. yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.16-10), avian acute (55), freshwater fish acute (1.5) and reproduction (2.3-4.0), aquatic invertebrate acute (27) and reproduction (32-58), estuarine fish acute (2.8) and reproduction (4.6-8.2), estuarine invertebrate acute (77) and reproduction (>280->500).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 5.1 ppm and whole fish of 3.5 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Risk quotients for chlorpyrifos sprayed three times on soybeans exceed the levels of concern for species in most non-target aquatic and terrestrial animals. Risk quotients for the three spray

applications are mammalian acute (0.006-3.1), subacute dietary (0.13-0.24), and reproduction NOEL (18-32), avian subacute dietary (1.3-2.3), and reproduction NOEL (7.1-13), freshwater fish acute (8.9) and reproduction (14-25), aquatic invertebrate acute (160) and reproduction (200-360), estuarine fish acute (17) and reproduction (28-51, estuarine invertebrate acute (460) and reproduction (>1700->3100).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 30 ppm and whole fish of 21 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Sunflower Uses**: Chlorpyrifos use on sunflowers is less than 1 percent of the total chlorpyrifos poundage. Chlorpyrifos is applied to less than 1 percent (likely maximum of less than 1 percent treated) of the approximately 2,700,000 acres of sunflowers grown in the U.S. According to BEAD, the typical chlorpyrifos usage on sunflowers is 1.1 application at 0.7 lbs ai/A on 7,000 to 13,000 acres. The leading states using about 81 percent of the chlorpyrifos applied to sunflowers are Minnesota, Colorado, California, and Kansas.

Directions for chlorpyrifos use on sunflowers on registered labels include both spray (the major use) and granular formulations. Chlorpyrifos granules are applied in a 7-inch wide, soil band application at-planting at 1.25 oz. ai/1000 feet of row. Chlorpyrifos is sprayed preplant at 1-2 lbs ai/A by ground equipment and soil incorporated (2 to 4 inches); and as a foliar spray is applied at a 7-day minimum interval by ground or aerial equipment. Assumes 24-inch row spacing. Maximum seasonal application rate is 4.5 lbs ai/A. The following 3 tables show the risk quotients for maximum chlorpyrifos use rates on sunflowers.

**Risk Quotients for Sunflowers**
**(Preplant Soil Incorporated (2 inches) Spray Treatment; 2 lb ai/A; 1 Application)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 270 - 480 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.6 - 4.7<br>1.8 - 3.3<br>0.42 - 0.74 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046- 0.42 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065- 0.58<br>0.046- 0.42<br>0.009- 0.084 |
| Mammalian Subacute Dietary $LC_{50}$ | 270 - 480 ppm | 1330 ppm | 0.20 - 0.36 |
| Mammalian Reproduction NOEL | 270 - 480 ppm | 10 ppm | 27 - 48 |
| Avian Subacute Dietary $LC_{50}$ | 270 - 480 ppm | 136 ppm | 2.0 - 3.5 |

| | | | |
|---|---|---|---|
| Avian Reproduction NOEL | 270 - 480 ppm | 25 ppm | 11 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 4.1 ppb | 1.8 ppb | 2.3 |
| Fish Reproduction NOEC | 2.0 - 3.8 ppb | 0.57 ppb | 3.5 - 6.7 |
| Aquatic Invertebrate Acute $LC_{50}$ | 4.1 ppb | 0.10 ppb | 41 |
| Freshwater Invert. Reproduction NOEC | 2.0 - 3.8 ppb | 0.04 ppb | 50 - 95 |
| Estuarine Fish Acute $LC_{50}$ | 4.1 ppb | 0.96 ppb | 4.3 |
| Estuarine Fish Reproduction NOEC | 2.0 - 3.8 ppb | 0.28 ppb | 7.1 - 14 |
| Estuarine Invertebrate Acute $LC_{50}$ | 4.1 ppb | 0.035 ppb | 120 |
| Estuarine Invert. Reproduction NOEC | 2.0 - 3.8 ppb | < 0.0046 ppb | > 430 > 830 |

**Granular Risk Quotients for Sunflowers**
**(At Planting, 1 Application at 1.25 oz. ai/1000 feet of row; 7-inch Band; Soil Incorporation, 1-inch)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on Formula** and GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 9.16 mg/ft$^2$ | 1.5 mg<br>3.4 mg<br>97 mg | 6.1<br>2.7<br>0.094 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 9.16 mg/ft$^2$ | 0.28 mg | 33 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 2.8 ppb | | 1.6 |
| Fish Reproduction NOEC | 0.57 ppb | 1.4 - 2.4 ppb | | 2.5 - 4.2 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 2.8 ppb | | 28 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.4 - 2.4 ppb | | 35 - 60 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 2.8 ppb | | 2.9 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.4 - 2.4 ppb | | 5.0 - 8.6 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 2.8 ppb | | 80 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.4 - 2.4 ppb | | > 300 > 520 |

* mg ai/ft$^2$ = $\frac{1.25 \text{ (oz ai/1000 ft row) X 28,349 mg/oz. X 15 \% exposed}}{\text{1,000 feet row X band width (0.58 ft.)}}$ = 9.16 mg ai./ft.$^2$

** lbs ai/A = $\frac{\text{1.25 (oz. ai./1000 feet of row) X 43560 ft}^2\text{/A}}{\text{16 oz./lb X 1000 ft X 2.0 row spacing (ft.)}}$ = 1.7 lbs ai/A

**Risk Quotients for Sunflowers**
**(Foliar Spray Treatment; 1.5 lb ai/A; 3 Applications; 7-day Interval)**
**(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 354 - 630 ppm | 102 ppm<br>147 ppm<br>647 ppm | 3.5 - 6.2<br>2.4 - 4.3<br>0.55 - 0.97 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 39 - 354 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.38 - 3.5<br>0.27 - 2.4<br>0.060- 0.55 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 39 - 354 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.084- 0.77<br>0.060- 0.55<br>0.012- 0.11 |
| Mammalian Subacute Dietary $LC_{50}$ | 354 - 630 ppm | 1330 ppm | 0.27 - 0.47 |
| Mammalian Reproduction NOEL | 354 - 630 ppm | 10 ppm | 35 - 63 |
| Avian Subacute Dietary $LC_{50}$ | 354 - 630 ppm | 136 ppm | 2.6 - 4.6 |
| Avian Reproduction NOEL | 354 - 630 ppm | 25 ppm | 14 - 25 |
| Freshwater Fish Acute $LC_{50}$ | 25 ppb | 1.8 ppb | 14 |
| Fish Reproduction NOEC | 12 - 22 ppb | 0.57 ppb | 21 - 39 |
| Aquatic Invertebrate Acute $LC_{50}$ | 25 ppb | 0.10 ppb | 250 |
| Freshwater Invert. Reproduction NOEC | 12 - 22 ppb | 0.04 ppb | 300 - 550 |
| Estuarine Fish Acute $LC_{50}$ | 25 ppb | 0.96 ppb | 26 |
| Estuarine Fish Reproduction NOEC | 12 - 22 ppb | 0.28 ppb | 43 - 79 |
| Estuarine Invertebrate Acute $LC_{50}$ | 25 ppb | 0.035 ppb | 710 |
| Estuarine Invert. Reproduction NOEC | 12 - 22 ppb | < 0.0046 ppb | >2600 > 4800 |

**Risk Summary for Maximum Use on Sunflowers**: Risk quotients for chlorpyrifos sprayed preplant on sunflowers exceed the levels of concern for species in most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.009-4.7), subacute dietary (0.20-0.36), and reproduction NOEL (27-48), avian subacute dietary (2.0-3.5), and reproduction NOEL (11-19), freshwater fish acute (2.3) and reproduction (3.5-6.7), aquatic invertebrate acute (41) and reproduction (50-95), estuarine fish acute (4.3) and reproduction (7.1-14), estuarine invertebrate acute (120) and reproduction (>430->830).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 7.8 ppm and whole fish of 5.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Chlorpyrifos granules applied in a 7-inch band at plant on sunflowers exceed the levels of concern for most non-target aquatic and terrestrial wildlife. Risk quotients are mammalian acute (0.094-6.1), avian acute (33), freshwater fish acute (1.6) and reproduction (2.5-4.2), aquatic invertebrate acute (28) and reproduction (35-60), estuarine fish acute (2.9) and reproduction (5.0-8.6), estuarine invertebrate acute (80) and reproduction (>300->520).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 5.5 ppm and whole fish of 3.8 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Chlorpyrifos sprayed 3 times on sunflowers at 1.5 lbs ai/A yield risk quotients which exceed the levels of concern for species in most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.012-6.2), subacute dietary (0.27-0.47), and reproduction NOEL (35-63), avian subacute dietary (2.6-4.6), and reproduction NOEL (14-25), freshwater fish acute (14) and reproduction (21-39), aquatic invertebrate acute (250) and reproduction (300-550), estuarine fish acute (26) and reproduction (300-550), estuarine invertebrate acute (710) and reproduction (>2600->4800).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 47 ppm and whole fish of 33 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

### (iv) Vegetable Crops and Strawberries

Chlorpyrifos may be applied to many kinds of vegetables. While there is a wide variety of treatments specific to a particular vegetable, two application methods are common for most vegetables (band treatment at plant and 6 foliar applications).

**Vegetable Uses**: Chlorpyrifos use on each vegetable and strawberries represents less than 1 percent of total chlorpyrifos poundage. Acreage and typical chlorpyrifos use rates on vegetables are listed by crop.

Directions for chlorpyrifos use on registered labels include both spray and granular formulations. Granules and spray may be applied by ground equipment at planting/transplanting or post-transplant as a 4-inch wide band over the row typically at maximum use rates of 1.4 oz. ai/1,000 feet of row (maximum use rates on some vegetables range from 1.2 to 1.8 oz. ai/1,000 feet of row). Six foliar applications at 1 lb ai/A may be sprayed with ground or aerial equipment. Peppers and tomatoes may be sprayed 8 times at 1 lb ai/A in Florida and Georgia.

Applications to the remaining field crops are of three types (slurry seed treatments, foliar sprays, and soil applications. Slurry seed treatments for stored seed (3 fl. oz. ai/cwt) and preplant seed (1 oz. ai/cwt), which are the same rates and result in the same risks as calculated for corn. Crops with treated seeds are beans and peas (both); cucumbers and pumpkins (preplant seeds only). Foliar applications are sprayed on asparagus foliar spray once or twice (1 lb ai/A, limited to AZ, CA, midwest, and Pacific northwest); carrots grown for seed (1 lb ai/A); and strawberries (twice at 1 lb ai/A). At plant soil applications include spraying broccoli raab (rapini) (2.25 lbs ai/A);

Chinese broccoli (gai lon) (2.25 lbs ai/A); bulb onions (0.045 lb ai/1000 ft soil drench at 0.035 lb ai/1000 ft); radish (granular and spray in-furrow at 0.5 oz. ai/1000 ft); radish grown for seed (2 lbs ai/A); strawberries (2 lbs ai/A, limited to ID, OR, and WA); sugar beets grown for seed are sprayed at 2 lb ai/A; and sweet potatoes at 2 lbs ai/A incorporated. Risk quotients for seed treatments are the same as for corn slurry seed treatments. The following 3 tables show the risk quotients for vegetable crops.

**Granular Risk Quotients for Vegetables**
**Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Chinese Cabbage,**
**Collards, Kale, Kohlrabi, Rutabagas, and Turnips**
**(4-Inch Band at Plant/transplant; 1 Application at 1.4 oz. ai/1000 ft; 2-inch Soil Incorporation)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on Formula** and GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 20 mg/$ft^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 13<br>5.9<br>0.21 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 20 mg/$ft^2$* | 0.28 mg | 71 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 3.2 ppb | | 1.8 |
| Fish Reproduction NOEC | 0.57 ppb | 1.6 - 2.7 ppb | | 2.8 - 4.7 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 3.2 ppb | | 32 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 1.6 - 2.7 ppb | | 40 - 68 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 3.2 ppb | | 3.3 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 1.6 - 2.7 ppb | | 5.7 - 9.6 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 3.2 ppb | | 91 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 1.6 - 2.7 ppb | | >350 > 590 |

* mg ai/$ft^2$ = $\frac{\text{(1.4 oz ai/1000 ft row) X 28,349 mg/oz. X 15 \% exposed}}{\text{1,000 feet row X band width (0.3 ft.)}}$ = 20 mg ai./$ft.^2$

** lbs ai/A = $\frac{\text{1.4 (oz. ai./1000 feet of row) X 43560 } ft^2/A}{\text{16 oz./lb X 1000 ft X 2.0 row spacing (ft.)}}$ = 1.9 lbs/A

**Risk Quotients for Vegetables**
**Broccoli*, Brussel Sprouts*, Cabbage*, Chinese Cabbage, Collards, Kale, Kohlrabi, and Turnips**
**(4-Inch Band Spray at Plant/transplant; 1 Application at 2.75 fl. oz. ai/1000 ft)**
**(Terrestrial EEC's Based on 11.3 lb ai/A in Band; Aquatic EEC's Based on GENEEC Model for 1.9 lb ai/A)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 170 - 1526 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.7 - 15<br>1.2 - 10<br>0.26 - 2.4 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 170 - 1526 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.37 - 3.3<br>0.26 - 2.4<br>0.053- 0.47 |
| Mammalian Subacute Dietary $LC_{50}$ | 170 - 1526 ppm | 1330 ppm | 0.13 - 1.1 |

| | | | |
|---|---|---|---|
| Mammalian Reproduction NOEL | 170 - 1526 ppm | 10 ppm | 17 - 150 |
| Avian Subacute Dietary $LC_{50}$ | 170 - 1526 ppm | 136 ppm | 1.2 - 11 |
| Avian Reproduction NOEL | 170 - 1526 ppm | 25 ppm | 6.8 - 61 |
| Freshwater Fish Acute $LC_{50}$ | 3.9 ppb | 1.8 ppb | 2.2 |
| Fish Reproduction NOEC | 1.9 - 3.4 ppb | 0.57 ppb | 3.3 - 6.0 |
| Aquatic Invertebrate Acute $LC_{50}$ | 3.9 ppb | 0.10 ppb | 39 |
| Freshwater Invert. Reproduction NOEC | 1.9 - 3.4 ppb | 0.04 ppb | 48 - 85 |
| Estuarine Fish Acute $LC_{50}$ | 3.9 ppb | 0.96 ppb | 4.1 |
| Estuarine Fish Reproduction NOEC | 1.9 - 3.4 ppb | 0.28 ppb | 6.8 - 12 |
| Estuarine Invertebrate Acute $LC_{50}$ | 3.9 ppb | 0.035 ppb | 110 |
| Estuarine Invert. Reproduction NOEC | 1.9 - 3.4 ppb | < 0.0046 ppb | >410 > 740 |

* In California, a second application may be applied when plants are thinned.

lb ai/A in band = $\frac{2.75 \text{ (fl oz/1,000 ft) X 4 lb ai/gal. X 43560 ft.}^2\text{/A}}{128 \text{ fl. oz./gal. X 1000 ft. X band width (0.33 ft.)}}$ = 11.3 lb ai/A in band

**Risk Quotients for Vegetables**
**Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Chinese Broccoli, Chinese Cabbage, Chinese Mustard, Collards, Kale, Kohlrabi, Mustard Greens, and Rape**
**(Aerial Foliar Spray; 6 Applications at 1 lb ai/A)**
**(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 266 - 472 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.6 - 4.6<br>1.8 - 3.2<br>0.41 - 0.73 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 266 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046- 0.41 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 266 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065- 0.58<br>0.046- 0.41<br>0.009- 0.082 |
| Mammalian Subacute Dietary $LC_{50}$ | 266 - 472 ppm | 1330 ppm | 0.20 - 0.35 |
| Mammalian Reproduction NOEL | 266 - 472 ppm | 10 ppm | 27 - 47 |
| Avian Subacute Dietary $LC_{50}$ | 266 - 472 ppm | 136 ppm | 2.0 - 3.5 |
| Avian Reproduction NOEL | 266 - 472 ppm | 25 ppm | 11 - 19 |
| Freshwater Fish Acute $LC_{50}$ | 32 ppb | 1.8 ppb | 18 |
| Fish Reproduction NOEC | 15 - 28 ppb | 0.57 ppb | 26 - 49 |
| Aquatic Invertebrate Acute $LC_{50}$ | 32 ppb | 0.10 ppb | 320 |
| Freshwater Invert. Reproduction NOEC | 15 - 28 ppb | 0.04 ppb | 380 - 700 |
| Estuarine Fish Acute $LC_{50}$ | 32 ppb | 0.96 ppb | 33 |

| | | | |
|---|---|---|---|
| Estuarine Fish Reproduction NOEC | 15 - 28 ppb | 0.28 ppb | 54 - 100 |
| Estuarine Invertebrate Acute $LC_{50}$ | 32 ppb | 0.035 ppb | 910 |
| Estuarine Invert. Reproduction NOEC | 15 - 28 ppb | < 0.0046 ppb | >3300 > 6100 |

**Risk Summary for Maximum Use Rates on Vegetables**: Granular band treatments with 1.4 oz. ai/A chlorpyrifos to vegetables yield risk quotients which exceed the level of concern for most non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.21-13), avian acute (71), freshwater fish acute (1.8) and reproduction (2.8-4.7), aquatic invertebrate acute (32) and reproduction (40-68), estuarine fish acute (3.3) and reproduction (5.7-9.6), estuarine invertebrate acute (91) and reproduction (>350->590).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 6.2 ppm and whole fish of 4.4 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Risk quotients for other granular band application rates (per 1000 feet of row) are less than 1.4 oz. discussed above: bulb onions (0.035 lb), and sugar beets (1.35 oz.).

An at-plant/transplant 4-inch band treatment of chlorpyrifos to vegetables listed in the above table yields risk quotients which exceed the levels of concern in most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.53-15), subacute dietary (0.13-1.1), and reproduction NOEL (17-150), avian subacute dietary (1.2-11) and reproduction NOEL (6.8-61), freshwater fish acute (2.2) and reproduction (3.3-6.0), aquatic invertebrate acute (39) and reproduction (48-85), estuarine fish acute (4.1) and reproduction (6.8-12), estuarine invertebrate acute (110) and reproduction (>410->740).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 7.4 ppm and whole fish of 5.2 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Lower risk quotients occur for other liquid soil applications, such as band, sidedress, soil drench, and soil injection applications (per 1000 feet of row) are: 0.04 lb on bulb onions, 0.5 oz. on radish, 1.2 oz. on cauliflower, 1.3 oz. on broccoli, cabbage, and 1.3 and 1.6 oz. on rutabagas, compared to the above 2.75 fl. oz. assessment.

Chlorpyrifos is sprayed as a 4-inch wide band over the row at plant with shallow soil incorporation. As the fields for these crops are usually well cultivated, short grass and other vegetation are unlikely. Insect and seeds may be sprayed and available to wildlife. While soil

incorporation does not reduce the pesticide concentration on sprayed items, soil may cover some items and reduce their availability.

Six aerial, foliar spray treatments of chlorpyrifos to vegetables listed in above table yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients for the six spray applications are mammalian acute (0.009-4.6), subacute dietary (0.20-0.35), and reproduction NOEL (27-47), avian subacute dietary (2.0-3.5) and reproduction NOEL (11-19), freshwater fish acute (18) and reproduction (26-49), aquatic invertebrate acute (320) and reproduction (380-700), estuarine fish acute (33) and reproduction (54-100), estuarine invertebrate acute (910) and reproduction (>3300->6100).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 59 ppm and whole fish of 41 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

### (v) Citrus Grove Applications (foliar, grove floor)

**Citrus Uses**: Citrus use represents about 3 percent of the total chlorpyrifos poundage. Chlorpyrifos is mainly applied to citrus as a air-blast, foliar spray with a minor use of granular formulations for grove floor applications. Registered citrus crops include grapefruit, lemons, oranges, and other citrus groves including limes, tangelos and tangerines. According to BEAD, chlorpyrifos is applied to oranges on about 14 percent (19 percent is likely maximum) of the total US acreage or approximately 120,000 to 165,000 acres; grapefruit on about 12 percent (16 percent is likely maximum) or approximately 23,000 to 32,000 acres; lemons on about 30 percent (43 percent is likely maximum) or approximately 19,000 to 27,000 acres; and other citrus (including kumquats, limes, tangelos and tangerines) on about 16 percent (32 percent is likely maximum) of the total US acreage or about 8,000 to 16,000 acres. Maximum and typical risks for chlorpyrifos on citrus are assessed only for applications to oranges, because oranges represent the highest use rate and largest acreage of any citrus crop.

Directions for chlorpyrifos use on oranges on registered labels include foliar spray and granular grove floor treatments. Two foliar applications may be sprayed with a minimum of 30-day interval. Treatments may be made either aerially or airblast by ground equipment. Use rates vary by geographic area (3.5 lbs ai/A in Florida and Texas; and 6 lbs ai/A in Arizona and California). The maximum seasonal use rate is 7.5 lbs ai/A.

Granules or spray soil broadcasts to grove floor may be applied at 1 lb ai/A with 10 applications per treatment (seasonal maximum of 10 lbs ai/A; limited to 3 lb ai/A EC in Florida). It is assumed that granules do not persist until the next application. Runoff from citrus orchards which usually have bare ground is typically higher than for pome and other orchards which have ground cover.

The use rate for residential citrus is 0.5 lb ai/100 gallons (600 ppm). Trunks may be sprayed at

0.625 lb ai/A (limited to California).

**Risk Quotients for Citrus**
**(Foliar Airblast Spray at 5 percent spray drift; 3.5 lbs ai/A; 2 Applications; 30-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on PRZM3-EXAMS Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 497 - 883 ppm | 102 ppm<br>147 ppm<br>647 ppm | 4.9 - 8.7<br>3.4 - 6.0<br>0.77 - 1.4 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 55 - 497 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.54 - 4.9<br>0.37 - 3.4<br>0.085- 0.77 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 55 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.12<br>0.085<br>0.017 |
| Mammalian Subacute Dietary $LC_{50}$ | 55 - 883 ppm | 1330 ppm | 0.041- 0.66 |
| Mammalian Reproduction NOEL | 55 - 883 ppm | 10 ppm | 5.5 - 88 |
| Avian Subacute Dietary $LC_{50}$ | 55 - 883 ppm | 136 ppm | 0.40- 6.5 |
| Avian Reproduction NOEL | 55 - 883 ppm | 25 ppm | 2.2 - 35 |
| Freshwater Fish Acute $LC_{50}$ | 27.6 ppb | 1.8 ppb | 15 |
| Fish Reproduction NOEC | 11.8- 21.4 ppb | 0.57 ppb | 21 - 38 |
| Aquatic Invertebrate Acute $LC_{50}$ | 27.6 ppb | 0.10 ppb | 280 |
| Freshwater Invert. Reproduction NOEC | 11.8- 21.4 ppb | 0.04 ppb | 300 - 540 |
| Estuarine Fish Acute $LC_{50}$ | 27.6 ppb | 0.96 ppb | 29 |
| Estuarine Fish Reproduction NOEC | 11.8- 21.4 ppb | 0.28 ppb | 42 - 76 |
| Estuarine Invertebrate Acute $LC_{50}$ | 27.6 ppb | 0.035 ppb | 790 |
| Estuarine Invert. Reproduction NOEC | 11.8- 21.4 ppb | < 0.0046 ppb | > 2600 > 4700 |

**Risk Summary for Maximum Citrus Spray Uses**: Two airblast spray treatments with chlorpyrifos to citrus yield risk quotients which exceed the level of concern for most non-target aquatic and terrestrial animals. The range of risk quotients for the two spray applications are mammalian acute (0.017-8.7), subacute dietary (0.041-0.66), and reproduction NOEL (5.5-88), avian subacute dietary (0.40-6.5), and reproduction NOEL (2.2-35), freshwater fish acute (1576) and reproduction (21-38), aquatic invertebrate acute (280) and reproduction (300-540), estuarine fish acute (29) and reproduction (42-76), estuarine invertebrate acute (790) and reproduction (>2600->4700). These risk quotients would be even higher for a single 6 lbs ai/A application in Arizona and California.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 59 ppm and whole fish of 41 ppm. These levels are less than the mammalian subacute LC50 value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels

in fish are less than the avian subacute LC50 value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Granular Risk Quotients for Citrus Grove Floor**
**(Soil Broadcast, Unincorporated; 1 lb ai/A; 10 Applications)**
**(Terrestrial EEC's Based on Formula* for one Application; Aquatic EEC's for 10 Applications Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 10.4 $mg/ft^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 6.9<br>3.1<br>0.11 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 10.4 $mg/ft^2$* | 0.28 mg | 37 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 30 ppb | | 17 |
| Fish Reproduction NOEC | 0.57 ppb | 15 - 26 ppb | | 26 - 46 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 30 ppb | | 300 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 15 - 26 ppb | | 370 - 650 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 30 ppb | | 31 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 15 - 26 ppb | | 53 - 93 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 30 ppb | | 860 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 15 - 26 ppb | | >3300 >5700 |

* mg ai/$foot^2$ = $\frac{1.0 \text{ lb ai/A X } 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2}$ = 10.4 $mg/ft^2$

**Risk Summary for Maximum Citrus Grove Floor Granular Uses**: Ten granular chlorpyrifos broadcast treatments to citrus grove floor yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The risk quotients are mammalian acute (0.11-6.9), avian acute oral (37), freshwater fish acute (17) and reproduction (26-46), aquatic invertebrate acute (300) and reproduction (370-650), estuarine fish acute (31) and reproduction (53-93), estuarine invertebrate acute (860) and reproduction (>3300->5700).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 59 ppm and whole fish of 41 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

The aquatic risk quotients are slightly less than the risk quotients presented below for ground spray, because ground spray produces 1 percent spray drift while granular formulations do not cause any spray drift; runoff is equal for both formulations.

| Risk Quotients for Citrus Grove Floor<br>(Ground Spray or Sprinkler Irrigation; 1 lb ai/A; 10 Applications; Assume 7-Day Interval)<br>(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores and (15 grams body wt.)<br>Mammalian Insectivores $LD_{50}$ (35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm<br>(no grass in<br>citrus groves) | 102 ppm<br>147 ppm<br>467 ppm | 0.29 - 2.6<br>0.20 - 1.8<br>0.046- 0.42 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 30 - 270 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.065- 0.58<br>0.046- 0.42<br>0.009- 0.084 |
| Mammalian Subacute Dietary $LC_{50}$ | 30 - 270 ppm | 1330 ppm | 0.022- 0.20 |
| Mammalian Reproduction NOEL | 30 - 270 ppm | 10 ppm | 3.0 - 27 |
| Avian Subacute Dietary $LC_{50}$ | 30 - 270 ppm | 136 ppm | 0.22- 2.0 |
| Avian Reproduction NOEL | 30 - 270 ppm | 25 ppm | 1.2 - 11 |
| Freshwater Fish Acute $LC_{50}$ | 34 ppb | 1.8 ppb | 19 |
| Fish Reproduction NOEC | 17 - 30 ppb | 0.57 ppb | 30 - 53 |
| Aquatic Invertebrate Acute $LC_{50}$ | 34 ppb | 0.10 ppb | 340 |
| Freshwater Invert. Reproduction NOEC | 17 - 30 ppb | 0.04 ppb | 420 - 750 |
| Estuarine Fish Acute $LC_{50}$ | 34 ppb | 0.96 ppb | 35 |
| Estuarine Fish Reproduction NOEC | 17 - 30 ppb | 0.28 ppb | 61 - 110 |
| Estuarine Invertebrate Acute $LC_{50}$ | 34 ppb | 0.035 ppb | 970 |
| Estuarine Invert. Reproduction NOEC | 17 - 30 ppb | < 0.0046 ppb | > 3700 > 6500 |

**Risk Summary for Maximum Citrus Grove Floor Spray Uses**: Ten soil broadcast spray treatments with chlorpyrifos to citrus yield risk quotients which exceed the level of concern for most non-target aquatic and terrestrial animals. Risk quotients for ten spray applications are mammalian acute (0.08-2.6), subacute dietary (0.02-0.2), and reproduction NOEL (3.0-27), avian subacute dietary (0.22-2.0), and reproduction NOEL (1.2-11), freshwater fish acute (19) and reproduction (30-53), aquatic invertebrate acute (340) and reproduction (420-750), estuarine fish acute (35) and reproduction (61-110), estuarine invertebrate acute (970) and reproduction (>3700->6500).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 66 ppm and whole fish of 46 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**California Citrus Field Study**: A California citrus field study reported the results of airblast treatments twice per season with chlorpyrifos. One set of orange groves were sprayed at 1.5 and

a second treatment at 6 lbs ai/A; and another set of groves were treated at 3.5 and 4.0 lbs ai/A. Chlorpyrifos residue levels were measured in various environmental samples and wildlife were observed for adverse effects.

Comparison of predicted residue levels of chlorpyrifos using the methodology in the above risk assessment with measured residue levels from a California orange field study are presented in the table below. In the field study, chlorpyrifos (i.e., Lorsban 4 E) was sprayed on two plots (A and B) with 4 fields each. Each field was treated with 2 applications: 1.5 plus 6.0 lbs ai/A on plots (A) and 3.5 plus 4.0 lbs ai/A on plots (B)). Soils were sampled to a depth of 1 inch. Residues on soils immediately after treatment is likely to be found in the top 1 cm. Chlorpyrifos residues in soil have not been modified in the tables below, but a reasonable estimate is that the residues may be 2.5 times higher than reported, at least initially.

| CHLORPYRIFOS IN CITRUS PLOTS (A) AIRBLAST AT 1.5 & 6.0 LB AI/A | | | | |
|---|---|---|---|---|
| Substrate (1st & 2nd Appl.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EEB Initial EEC |
| 1st Soil (1 in.) | 2.28 ppm | 0.56-4.45 ppm | 5.68 ppm | 3.3 ppm |
| 2nd Soil (1 in.) | 6.65 ppm | 0.66-22.1 ppm | 48.1 ppm | 13.4 ppm |
| 1st Crop Foliage | 29.9 ppm | 17.8-42.8 ppm | 61.6 ppm | 202.5 ppm |
| 2nd Crop Foliage | 166 ppm | 61.0-310 ppm | 376.2 ppm | 820 ppm |
| 1st Non-crop Foliage | 6.13 ppm | 0.76-12.4 ppm | 23.77 ppm | 10.1 ppm |
| 2nd Non-crop Foliage | 36.4 ppm | 8.61-68.9 ppm | 179.22 ppm | 41 ppm |
| 1st Invertebrates | 5.49 ppm | 3.73-5.89 ppm | 13.9 ppm | 22.5 ppm |
| 2nd Invertebrates | 14.2 ppm | 5.00-22.1 ppm | 34.79 ppm | 23.6 ppm |
| 1st Water (ppb) | < 1.0 ppb | not detected | < 1.0 ppb | 7.64[b] ppb |
| 2nd Water (ppb) | 244[a] ppb | 1.12-486 ppb | 486 ppb | 21.4-27.6[c] ppb |

[a] Two water samples on Day 1 reported 1.18 ppb and 486.135 ppb in the only two samples collected on Day 1 of the second application at 6 lbs ai/A.

[b] Aquatic EECs for 96-hour and peak conc. for airblast spray (GENEEC Model)

[c] EECs for 96-hour and peak conc. for airblast spray (PRZM3-EXAMS Model)

| CHLORPYRIFOS IN CITRUS PLOTS (B) AIRBLAST AT 3.5 & 4.0 LB AI/A | | | | |
|---|---|---|---|---|
| Substrate (1st & 2nd Appl.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EEB Initial EEC |
| 1st Soil (1 in.) | 7.63 ppm | 6.23-9.37 ppm | 13.41 ppm | 7.71 ppm |
| 2nd Soil (1 in.) | 7.81 ppm | 2.70-17.1 ppm | 28.4 ppm | 8.82 ppm |
| 1st Crop Foliage | 110 ppm | 77.4-167 ppm | 220 ppm | 472.5 ppm |
| 2nd Crop Foliage | 117 ppm | 46.5-209 ppm | 305.8 ppm | 564 ppm |
| 1st Non-crop Foliage | 21.9 ppm | 12.8-41.8 ppm | 91.7 ppm | 23.6 ppm |

| | | | | |
|---|---|---|---|---|
| 2nd Non-crop Foliage | 80.6 ppm | 22.9-182 ppm | 344.82 ppm | 28.2 ppm |
| 1st Invertebrates | 4.53 ppm | 3.11-5.44 ppm | 8.99 ppm | 52.5 ppm |
| 2nd Invertebrates | 4.99 ppm | 4.19-5.67 ppm | 6.97 ppm | 62.7 ppm |
| 1st Water (ppb) | 0.77[a] ppb | 12.0-0.77 ppb | 1.041 ppb | 18.02[b] ppb |
| 2nd Water (ppb) | 1.63[a] ppb | <1.0-1.63 ppb | 2.27 ppb | 29.7[c] ppb |

[a] Water sample on Day 4 reported 1.041 ppb, substituted for Day 0 levels
[b] Aquatic EECs were estimated using the GENEEC Model for airblast
[c] EFGWB's estimated EEC in water was 27.6 ppb using PRZM3-EXAMS Model for 2 applications at 3.5 lbs ai/A

Comparison of measured chlorpyrifos residue levels and estimated EECs indicate that EECs are generally comparable to measured levels. Soil EECs are within the range of mean measured for all four comparisons. As a conservative estimate of risk, the EECs of pesticide residue levels on foliage and on/in invertebrates are based on upper residue levels, not mean residue levels. Crop foliar EECs exceed the highest measured levels on crop foliage by 2 to 3 fold (only 3 measured samples per replicate, 12 per treatment, were collected immediately after application). Assuming that 5 percent spray drift to adjacent vegetation, non-crop foliage EECs are consistently less than the measured residue levels (2 to 12 fold). Without knowing what invertebrates were sampled, it is assumed that the residues would be 15 ppm per lb ai/A applied. EECs for invertebrates are exceeded by the highest measured residue levels in 3 out of 4 cases (2 to 9 fold).

Predicted aquatic EECs for citrus use were within the range of measured chlorpyrifos levels in adjacent bodies of water, despite many indiscernible environmental variables. Comparability of aquatic EECs with measured residues in adjacent bodies of water is dependent on many non-chemical specific factors which may not be known, such as rainfall, runoff, treated fields and adjacent water body.. Runoff to aquatic areas is an episodic event which depends on the frequency, intensity, and amount of rainfall, as well as soil type, soil water content, slope and ground cover. The chemical loading is also dependent on what percentage of the drainage area has been treated, the width and type of vegetative buffer strip, and the proximity of the treated field to the water. Also important are the dilution factors, such as the depth and volume of the water body, is the water impounded or flowing, and the amount of suspended particulates and organic matter in the water. Given all these variables, exact estimates of EECs are unlikely. Despite these numerous factors and the infrequency of rain in California, the predicted EECs (7.64 to 29.7 ppb) were bracketed by the range of actual measured chlorpyrifos levels in the water (non-detect to 486 ppb). Measured chlorpyrifos levels in water which ranged from 1.041 to 486 ppb, were found in the water bodies adjacent to half of the treated fields in this study (i.e., replicates A2, A3, B1, and B2).

**Wildlife Mortality and Sublethal Observations**: Results from the California citrus field study confirmed risks to terrestrial wildlife and aquatic organisms. The results from wildlife searches yielded a total of 116 carcasses in chlorpyrifos-treated citrus groves. Only 21 carcasses were analyzed for chlorpyrifos residues and six of the 21 carcasses (28.6 %) were found to have chlorpyrifos residues either in the carcass or on their pelt and consequently it is assumed that they

may have died from treatments. Out of forty carcasses found in citrus groves sprayed at 1.5 lbs ai/A, 7 carcasses were tested for chlorpyrifos and no carcasses were found to contain measureable levels of chlorpyrifos. Out of 31 carcasses found after a second application at 6 lbs ai/A, 7 carcasses were analyzed and chlorpyrifos was found on or in 4 carcasses (i.e., 5.39 ppm on the pelt of a mockingbird, 1.53 ppm on a ground squirrel pelt, 1.51 ppm on a pocket gopher's pelt, and 1.74 ppm and 6.94 ppm in the carcass and on the pelt of a western rattlesnake, respectively. Out of thirty carcasses found in citrus groves sprayed at 3.5 lbs ai/A, 6 carcasses were analyzed for chlorpyrifos and one carcass contained 0.610 ppm chlorpyrifos in the whole house mouse. Out of 15 carcasses found after a second application at 4 lbs ai/A, 1 carcass was analyzed for chlorpyrifos and 3.67 ppm was found in the young passerine nestling. Carcasses found on reference (control) replicates were not analyzed for the cause of death, because the authors assumed that all reference deaths represent natural deaths. Carcass recovery rates ranged from 21.8 to 26.3 % for the grove interior, 24.1 to 31.3 % for the grove perimeter, and 14.0 to 18.9 % for the adjacent habitat.

Residues in the rattlesnake are difficult to understand, unless the snake died after eating one or more animals which were poisoned by chlorpyrifos. If the death of the rattlesnake was caused by eating poisoned animals, it is the first known example of secondary toxicity with chlorpyrifos (i.e., residues in a dead carcass killing a scavenger). If secondary toxicity was the cause of death for the rattlesnake, other scavenging animal species might be also be at risk.

Measured chlorpyrifos levels ranging from 1.041 to 486 ppb, were found in water adjacent to half of the treated fields in this study (i.e., A2, A3, B1, and B2). Chlorpyrifos levels of 1 ppb and higher would be lethal to aquatic invertebrates, tadpoles, and small fish. The 486 ppb chlorpyrifos in water exceeds the LC50 values for all 10 freshwater and 11 estuarine fish species as well as all 4 aquatic and 6 estuarine invertebrate species for which LC50 values are available.

Although the field study was limited to collection of residue samples and observation of terrestrial effects, dead fish were found in ponds next to chlorpyrifos-treated citrus groves. The fish kills occurred, even though rainfall was slight in only one replicate during the study. The authors collected the dead fish and sent the dead fish to Dow Chemical Company.

Typical Citrus Use: According to BEAD, considerable differences exist between usage on different citrus crops ranging from 1.2 lbs ai/A on limes, tangelos and tangerines to 2.9 lbs ai/A on oranges. Typically, second applications are made to all citrus crops. The typical use rate on oranges is about 1.3 applications at an average rate of about 2.9 lbs ai/A on approximately 120,000 to 160,000 acres with a second application on 30 percent of the treated orange acreage. Since oranges are the largest use on citrus, the risk quotients presented below are for the typical use on oranges. The leading states using 96 percent of the chlorpyrifos applied to oranges are California and Florida. According to Dow (1999 responses), the typical use for chlorpyrifos on oranges is a single foliar, air blast application at 6.0 lbs ai/A in California.

| Risk Quotients for Typical Use on Oranges<br>(Foliar, Air Blast Spray with 5 Percent spray Drift; 1 Application at 6.0 lbs ai/A)<br>(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Surrogate Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 810 - 1440 ppm | 102 ppm<br>147 ppm<br>647 ppm | 7.9 - 14<br>5.5 - 9.8<br>1.3 - 2.2 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 90 - 810 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.88 - 7.9<br>0.61 - 5.5<br>0.14 - 1.3 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 90 - 810 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.19 - 1.8<br>0.14 - 1.3<br>0.028 - 0.25 |
| Mammalian Subacute Dietary $LC_{50}$ | 90 - 1440 ppm | 1330 ppm | 0.068 - 1.1 |
| Mammalian Reproduction NOEL | 90 - 1440 ppm | 10 ppm | 9.0 - 140 |
| Avian Subacute Dietary $LC_{50}$ | 90 - 1440 ppm | 136 ppm | 0.66 - 11 |
| Avian Reproduction NOEL | 90 - 1440 ppm | 25 ppm | 3.6 - 58 |
| Freshwater Fish Acute $LC_{50}$ | 30.9 ppb | 1.8 ppb | 17 |
| Fish Reproduction NOEC | 15.6 -27.6 ppb | 0.57 ppb | 27 - 48 |
| Aquatic Invertebrate Acute $LC_{50}$ | 30.9 ppb | 0.10 ppb | 310 |
| Freshwater Invert. Reproduction NOEC | 15.6 -27.6 ppb | 0.04 ppb | 390 - 690 |
| Estuarine Fish Acute $LC_{50}$ | 30.9 ppb | 0.96 ppb | 32 |
| Estuarine Fish Reproduction NOEC | 15.6 -27.6 ppb | 0.28 ppb | 56 - 99 |
| Estuarine Invertebrate Acute $LC_{50}$ | 30.9 ppb | 0.035 ppb | 880 |
| Estuarine Invert. Reproduction NOEC | 15.6 -27.6 ppb | < 0.0046 ppb | > 3400 > 6000 |

**Risk Summary for Typical Citrus Foliar Use**: Risk quotients derived for a single application at the typical use rate at 6.0 lbs ai/A on oranges exceed the levels of concern of most non-target aquatic and terrestrial animals. The range of RQs for a typical application is as follows: mammalian acute (0.028-14) and reproduction (9.0-140), avian acute (0.66-11) and reproduction (3.6-58), freshwater fish acute (17) and reproduction (27-48), freshwater invertebrates acute (310) and reproduction (390-690), estuarine fish acute (32) and reproduction (56-99), and estuarine invertebrates acute (880) and reproduction (>3400->6000).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 61 ppm and whole fish of 43 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

Wildlife utilization of citrus groves ranges from low to a moderate and high degree for a broad diversity of avian and mammalian species (Gusey and Maturgo 1973). Mammals reported to feed moderately in citrus groves, include raccoons and deer. Mourning doves, pheasants and 13 species of birds are listed as nesting in citrus groves. During the California orange field study, between 188 to 561 birds were observed on plots in orange groves. While it is unlikely that deer might be adversely affected, because of its large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated citrus fields. Wildlife carcasses with chlorpyrifos residues found in the field study included a mockingbird, ground squirrel, pocket gopher and a western rattlesnake.

### (vi) Fruit and Nut Orchard Applications (dormant, foliar, trunk &/or soil floor)

According to BEAD, pome orchards represent about 3 percent of the total poundage, and stone fruits, almonds, and other nuts are all less than 1 percent. Apples are the highest use of chlorpyrifos in this category with about 44 to 53 percent of the acreage treated or about 250,000 to 300,000 acres. Apple uses total about 77 percent in decreasing order in the following states: Washington, Minnesota, New York, California, Vermont, and North Carolina. Pecans are the next highest use of chlorpyrifos in this category with approximately 140,000 to 170,000 acres treated in Texas, Georgia, Louisiana, and Oklahoma totaling about 85 percent. Other nut orchards include: walnuts in California (100 percent), almonds in California (100 percent), chestnuts, filberts (hazelnuts) and macadamia nuts. Other crops included in this category as fruits are cranberries and grapes. Figs are limited to use in California and macadamia nuts are limited to use in Hawaii.

Directions for chlorpyrifos use on registered labels are limited to spray treatments for fruit and nut trees. Four basic spray treatments are used for fruit and nut trees: 1 application on dormant trees; 1 to 3 trunk (bark) applications (8 applications on macadamia nuts); 2 to 8 foliar applications; and 1 to 5 soil, spray broadcast treatments to orchard floors.

**Dormant Tree Uses**: BEAD's Quantitative Usage Analysis does not differentiate between the poundage of chlorpyrifos used as dormant sprays on trees, foliar and orchard floor treatments.

Directions for chlorpyrifos use on registered labels are for a single, dormant treatment sprayed airblast by ground equipment at 0.5 lb ai/100 gallon at 200-600 finished spray/A (i.e., 2-3 lbs ai.A) on apples, nectarines, peaches, pears, plums and prunes. A single, dormant application on almonds and walnuts sprayed at 2 lb ai/A or 2 lb ai/100 gallons. Trunk (bark) applications to be sprayed at 3 lbs ai/100 gallons using ground equipment on almonds (2 applications at a minimum retreatment interval of 60 days), sweet cherries (3 applications at minimum interval of 14 days), and one application to nectarines and peaches. Non-bearing, preplant peaches may be dip treated at 3 lbs/100 gallons. Dipping and bark applications can be assessed for wildlife risks, but spraying to runoff is difficult to quantify for aquatic exposures. The following table shows the risk quotients for dormant uses on fruit trees at 3 lbs ai./A.

| Risk Quotients for Apples, Nectarines, Peaches, Pears, Plums, and Prunes (Dormant Ground Airblast Spray; 3 lbs ai/A; 1 Application) (Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 405 - 720 ppm | 102 ppm<br>147 ppm<br>647 ppm | 4.0 - 7.1<br>2.8 - 4.9<br>0.63 - 1.1 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45 - 405 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.44 - 4.0<br>0.31 - 2.8<br>0.070- 0.63 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45 - 405 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.097- 0.88<br>0.070- 0.63<br>0.014- 0.13 |
| Mammalian Subacute Dietary $LC_{50}$ | 405 - 720 ppm | 1330 ppm | 0.30 - 0.54 |
| Mammalian Reproduction NOEL | 405 - 720 ppm | 10 ppm | 40 - 72 |
| Avian Subacute Dietary $LC_{50}$ | 405 - 720 ppm | 136 ppm | 3.0 - 5.3 |
| Avian Reproduction NOEL | 405 - 720 ppm | 25 ppm | 16 - 29 |
| Freshwater Fish Acute $LC_{50}$ | 15.4 ppb | 1.8 ppb | 8.6 |
| Fish Reproduction NOEC | 7.6 -13.7 ppb | 0.57 ppb | 13 - 24 |
| Aquatic Invertebrate Acute $LC_{50}$ | 15.4 ppb | 0.10 ppb | 150 |
| Freshwater Invert. Reproduction NOEC | 7.6 -13.7 ppb | 0.04 ppb | 190 - 340 |
| Estuarine Fish Acute $LC_{50}$ | 15.4 ppb | 0.96 ppb | 16 |
| Estuarine Fish Reproduction NOEC | 7.6 -13.7 ppb | 0.28 ppb | 27 - 49 |
| Estuarine Invertebrate Acute $LC_{50}$ | 15.4 ppb | 0.035 ppb | 440 |
| Estuarine Invert. Reproduction NOEC | 7.6 -13.7 ppb | < 0.0046 ppb | > 1700 > 3000 |

**Risk Summary for Maximum Dormant Tree Uses**: Chlorpyrifos sprayed airblast on dormant fruit and nut trees at 3 lbs ai/A yields risk quotients which exceed the level of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.014-7.1), subacute (0.30-0.54) and reproduction NOEL (40-72), avian subacute (3.0-5.3) and reproduction NOEL (16-29), freshwater fish acute (8.6) and reproduction (13-24), aquatic invertebrate acute (150) and reproduction (190-340), estuarine fish acute (16) and reproduction (27-49), estuarine invertebrate acute (440) and reproduction (>1700->3000).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 30 ppm and whole fish of 21 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

Aquatic EECs calculated with the GENEEC Model for dormant uses are probably slightly high

and overestimate the aquatic EECs. While spray drift from airblast would be about 5 percent, runoff is likely to be reduced, because these orchards usually have grass or a ground cover around the trees. The ground cover reduces soil erosion and generally would yield lower aquatic risks via runoff than those modelled for citrus, which have usually have bare ground.

Chlorpyrifos (level of detection 40 ng/L) was measured as trace to 42 ng/L in the San Joaquin River at Vernalis, California daily between February 9 and 18, 1993 are attributed to dormant spray use of about 17,500 kg of chlorpyrifos on fruit trees in the San Joaquin Valley (Kuivila and Foe, 1995).

**Summary of Risks for Dormant Walnut Use**: Risk quotients for dormant airblast treatments of almond and walnut trees sprayed at 2 lbs ai/A are about two-thirds of the above RQ values.

**Fruit and Nut Foliar Uses**: Foliar chlorpyrifos applications are sprayed with ground or aerial equipment 5 times at 2 lbs ai/A on pecans, 3 times at 2 lbs ai/A or 2 lbs/100 gallons to almonds, filberts and walnuts; 8 times at 1.5 lbs ai/A or 1.5 lb ai/100 gal. to apples (21 day interval between final two applications) and to sour cherries). Foliar applications on grapes at 1 lb ai/A with ground equipment at pre-bloom in Michigan and Missouri and with ground or aerial equipment on non-bearing vines in Idaho, Oregon, and Washington. The following two tables show the minimum and maximum risk quotients for nut and fruit tree foliar treatments.

**Risk Quotients for Almonds and Filberts**
**(Foliar Aerial Spray Treatment; 2 lbs ai/A; 3 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 236 - 420 ppm | 102 ppm<br>147 ppm<br>647 ppm | 2.3 - 4.1<br>1.6 - 2.9<br>0.36 - 0.65 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 26 - 236 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.25 - 2.3<br>0.18 - 1.6<br>0.040- 0.36 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 26 - 236 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.056- 0.51<br>0.040- 0.36<br>0.008- 0.073 |
| Mammalian Subacute Dietary $LC_{50}$ | 236 - 420 ppm | 1330 ppm | 0.18 - 0.32 |
| Mammalian Reproduction NOEL | 236 - 420 ppm | 10 ppm | 24 - 42 |
| Avian Subacute Dietary $LC_{50}$ | 236 - 420 ppm | 136 ppm | 1.7 - 3.1 |
| Avian Reproduction NOEL | 236 - 420 ppm | 25 ppm | 9.4 - 17 |
| Freshwater Fish Acute $LC_{50}$ | 33 ppb | 1.8 ppb | 18 |
| Fish Reproduction NOEC | 16 - 29.4 ppb | 0.57 ppb | 28 - 52 |
| Aquatic Invertebrate Acute $LC_{50}$ | 33 ppb | 0.10 ppb | 330 |
| Freshwater Invert. Reproduction NOEC | 16 - 29.4 ppb | 0.04 ppb | 400 - 740 |

| | | | |
|---|---|---|---|
| Estuarine Fish Acute $LC_{50}$ | 33 ppb | 0.96 ppb | 34 |
| Estuarine Fish Reproduction NOEC | 16 - 29.4 ppb | 0.28 ppb | 57 - 110 |
| Estuarine Invertebrate Acute $LC_{50}$ | 33 ppb | 0.035 ppb | 940 |
| Estuarine Invert. Reproduction NOEC | 16 - 29.4 ppb | < 0.0046 ppb | > 3500 > 6400 |

**Risk Summary for Maximum Almond and Filbert Foliar Uses**: Chlorpyrifos sprayed by airblast on almond trees three times at 2 lbs ai/A yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.008-4.1), subacute (0.18-0.32) and reproduction NOEL (24-42), avian subacute (1.7-3.1) and reproduction NOEL (9.4-17), freshwater fish acute (18) and reproduction (28-52), aquatic invertebrate acute (330) and reproduction (400-740), estuarine fish acute (34) and reproduction (107-200), estuarine invertebrate acute (940) and reproduction (>3500->6400).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 62 ppm and whole fish of 44 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Risk Quotients for Apples and Sour Cherries**
**(Foliar Aerial Spray Treatment; 1.5 lbs ai/A; 8 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 403 - 717 ppm | 102 ppm<br>147 ppm<br>647 ppm | 4.0 - 7.0<br>2.7 - 4.9<br>0.62 - 1.1 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45 - 403 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.44 - 4.0<br>0.31 - 2.7<br>0.070- 0.62 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 45 - 403 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.097- 0.87<br>0.070- 0.62<br>0.014- 0.12 |
| Mammalian Subacute Dietary $LC_{50}$ | 403 - 717 ppm | 1330 ppm | 0.30 - 0.54 |
| Mammalian Reproduction NOEL | 403 - 717 ppm | 10 ppm | 40 - 71 |
| Avian Subacute Dietary $LC_{50}$ | 403 - 717 ppm | 136 ppm | 3.0 - 5.3 |
| Avian Reproduction NOEL | 403 - 717 ppm | 25 ppm | 16 - 29 |
| Freshwater Fish Acute $LC_{50}$ | 61.8 ppb | 1.8 ppb | 34 |
| Fish Reproduction NOEC | 30 - 55 ppb | 0.57 ppb | 53 - 96 |
| Aquatic Invertebrate Acute $LC_{50}$ | 61.8 ppb | 0.10 ppb | 620 |
| Freshwater Invert. Reproduction NOEC | 30 - 55 ppb | 0.04 ppb | 750 - 1400 |

| | | | |
|---|---|---|---|
| Estuarine Fish Acute $LC_{50}$ | 61.8 ppb | 0.96 ppb | 64 |
| Estuarine Fish Reproduction NOEC | 30 - 55 ppb | 0.28 ppb | 107 - 200 |
| Estuarine Invertebrate Acute $LC_{50}$ | 61.8 ppb | 0.035 ppb | 1800 |
| Estuarine Invert. Reproduction NOEC | 30 - 55 ppb | < 0.0046 ppb | > 6500 >12000 |

**Risk Summary for Maximum Fruit Tree Foliar Uses**: Eight aerial spray treatments with chlorpyrifos to pome fruit trees at 1.5 lbs ai/A yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.014-7.0), subacute dietary (0.3-0.54) and reproduction NOEL (40-71), avian subacute dietary (3.0-5.3) and reproduction NOEL (16-29), fresh-water fish acute (34) and reproduction (53-96), aquatic invertebrate acute (620) and reproduction (750-1400), estuarine fish acute (64) and reproduction (107-200), estuarine invertebrate acute (1800) and reproduction (>6500->12000).

Food chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 117 ppm and whole fish of 82 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Trunk Applications to Macadamia Nut Uses**: Tree trunks of macadamia nuts are sprayed with ground equipment 8 times at 1 lb ai/A with a minimum retreatment interval of 30 days (use limited to Hawaii).
**Risk Summary for Maximum Foliar Macadamia Nut Uses**: Risk quotients for macadamia nut trees sprayed 8 times at 1 lb ai/A are less than the above RQ values for the 8 foliar application to sour cherries.

**Cranberry Uses**: Applications to cranberries are foliar sprays applied twice per season at 1.5 lbs ai/A. Cranberries may not be treated when the bogs are flooded. The following table shows the risk quotients for cranberry use.

**Risk Quotients for Cranberries**
**(Foliar Aerial Spray; 1.5 lbs ai/A; 2 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.) | 303 - 540 ppm | 102 ppm | 3.0 - 5.3 |
| (35 grams body wt.) | | 147 ppm | 2.1 - 3.7 |
| (1000 grams body wt.) | | 647 ppm | 0.47 - 0.83 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.) | 34 - 303 ppm | 102 ppm | 0.33 - 3.0 |
| (35 grams body wt.) | | 147 ppm | 0.23 - 2.1 |
| (1000 grams body wt.) | | 647 ppm | 0.053- 0.47 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.) | 34 - 303 ppm | 462 ppm | 0.074- 0.66 |
| (35 grams body wt.) | | 647 ppm | 0.053- 0.47 |
| (1000 grams body wt.) | | 3233 ppm | 0.011- 0.094 |

| | | | |
|---|---|---|---|
| Mammalian Subacute Dietary $LC_{50}$ | 303 - 540 ppm | 1330 ppm | 0.23 - 0.41 |
| Mammalian Reproduction NOEL | 303 - 540 ppm | 10 ppm | 30 - 54 |
| Avian Subacute Dietary $LC_{50}$ | 303 - 540 ppm | 136 ppm | 2.2 - 4.0 |
| Avian Reproduction NOEL | 303 - 540 ppm | 25 ppm | 12 - 22 |
| Freshwater Fish Acute $LC_{50}$ | 16.7 ppb | 1.8 ppb | 9.3 |
| Fish Reproduction NOEC | 8.1 - 15 ppb | 0.57 ppb | 14 - 26 |
| Aquatic Invertebrate Acute $LC_{50}$ | 16.7 ppb | 0.10 ppb | 170 |
| Freshwater Invert. Reproduction NOEC | 8.1 - 15 ppb | 0.04 ppb | 200 - 380 |
| Estuarine Fish Acute $LC_{50}$ | 16.7 ppb | 0.96 ppb | 17 |
| Estuarine Fish Reproduction NOEC | 8.1 - 15 ppb | 0.28 ppb | 29 - 54 |
| Estuarine Invertebrate Acute $LC_{50}$ | 16.7 ppb | 0.035 ppb | 480 |
| Estuarine Invert. Reproduction NOEC | 8.1 - 15 ppb | < 0.0046 ppb | > 1800 > 3300 |

**Risk Summary for Cranberry Use**: Two aerial spray treatments with chlorpyrifos to cranberries at 1.5 lbs ai/A yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.011-5.3), subacute dietary (0.23-0.41) and reproduction NOEL (30-54), avian subacute dietary (2.2-4.0) and reproduction NOEL (12-22), freshwater fish acute (9.3) and reproduction (14-26), aquatic invertebrate acute (170) and reproduction (200-380), estuarine fish acute (17) and reproduction (29-54), estuarine invertebrate acute (480) and reproduction (>1800->3300).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 32 ppm and whole fish of 22 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

Aerial applications on cranberries are a particular concern, because spray drift to adjacent freshwater and estuarine areas poses very high risks to sensitive aquatic species. Concern also exists for the flooding and drainage of chlorpyrifos-treated cranberry bogs into freshwater and estuarine areas.

**Grape Uses**: Grapes applications may be soil sprayed at 2.25 lbs ai/100 gallons (2 quarts finished spray per 15 sq. ft.), foliar at 1.125 lb ai/100 gallons (2 quarts finished spray per 15 sq. ft.), a prebloom, foliar, ground application at 1 lb ai/A (use limited to MI and MO), and non-bearing, foliar spray by ground or aerial equipment at 1 lb ai/A (use limited to Idaho, Oregon, and Washington). The following table shows the risk quotients for foliar grape uses.

| Risk Quotients for Grapes<br>(Foliar Aerial Spray; 1 lb ai/A; 1 Application)<br>(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model) | | | |
|---|---|---|---|
| **Species** | **Exposure** | **Toxicity** | **Risk Quotient** |
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 135 - 240 ppm | 102 ppm<br>147 ppm<br>647 ppm | 1.3 - 2.4<br>0.92 - 1.6<br>0.21 - 0.37 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 - 135 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.15 - 1.3<br>0.10 - 0.92<br>0.023- 0.21 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 15 - 135 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.032- 0.29<br>0.023- 0.21<br>0.005- 0.042 |
| Mammalian Subacute Dietary $LC_{50}$ | 135 - 240 ppm | 1330 ppm | 0.10 - 0.18 |
| Mammalian Reproduction NOEL | 135 - 240 ppm | 10 ppm | 14 - 24 |
| Avian Subacute Dietary $LC_{50}$ | 135 - 240 ppm | 136 ppm | 0.99- 1.8 |
| Avian Reproduction NOEL | 135 - 240 ppm | 25 ppm | 5.4 - 9.6 |
| Freshwater Fish Acute $LC_{50}$ | 5.1 ppb | 1.8 ppb | 2.8 |
| Fish Reproduction NOEC | 2.5 - 4.6 ppb | 0.57 ppb | 4.4 - 8.1 |
| Aquatic Invertebrate Acute $LC_{50}$ | 5.1 ppb | 0.10 ppb | 51 |
| Freshwater Invert. Reproduction NOEC | 2.5 - 4.6 ppb | 0.04 ppb | 62 - 120 |
| Estuarine Fish Acute $LC_{50}$ | 5.1 ppb | 0.96 ppb | 5.3 |
| Estuarine Fish Reproduction NOEC | 2.5 - 4.6 ppb | 0.28 ppb | 8.9 - 16 |
| Estuarine Invertebrate Acute $LC_{50}$ | 5.1 ppb | 0.035 ppb | 150 |
| Estuarine Invert. Reproduction NOEC | 2.5 - 4.6 ppb | < 0.0046 ppb | > 540 > 1000 |

**Risk Summary for Grape Uses**: Chlorpyrifos aerially sprayed onto grapes at 1 lb ai/A yields risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.005-2.4), subacute (0.10-0.18) and reproduction NOEL (14-24), avian subacute (0.99-1.8) and reproduction NOEL (5.4-9.6), freshwater fish acute (2.8) and reproduction (4.4-8.1), aquatic invertebrate acute (51) and reproduction (62-120), estuarine fish acute (5.3) and reproduction (8.9-16), estuarine invertebrate acute (150) and reproduction (>540->1000).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 9.8 ppm and whole fish of 6.8 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

**Fruit and Nut Orchard Floor Uses**: Soil broadcast treatments on grove floor are sprayed by

ground equipment on almonds twice at 4 lbs ai/A, on pecans 5 times at 2 lbs ai/A, on dormant figs once at 2 lbs ai/A with 3-inch soil incorporation (use limited to California), on soil surface on a 15-square foot area around the base of each grape vine once at 2.25 lb/100 gal. (2 quarts of finished spray/ 15 sq. ft.) not letting spray contact fruit or foliage (use limited to east of Rocky Mountains) or sprayed twice at 1.125 lb ai/100 gal. (use limited to Georgia and Tennessee). The two following tables show risk quotients for almond and pecans orchard floor uses.

**Risk Quotients for Almond Orchard Floor**
**(Soil Broadcast Ground Spray Treatment; 4 lbs ai/A; 2 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 810 - 1440 ppm | 102 ppm<br>147 ppm<br>647 ppm | 7.9 - 14<br>5.5 - 9.8<br>1.3 - 2.2 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 90 - 810 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.88 - 7.9<br>0.61 - 5.5<br>0.14 - 1.3 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 90 - 810 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.19 - 1.8<br>0.14 - 1.3<br>0.028- 0.25 |
| Mammalian Subacute Dietary $LC_{50}$ | 810 - 1440 ppm | 1330 ppm | 0.61 - 1.1 |
| Mammalian Reproduction NOEL | 810 - 1440 ppm | 10 ppm | 81 - 140 |
| Avian Subacute Dietary $LC_{50}$ | 810 - 1440 ppm | 136 ppm | 6.0 - 11 |
| Avian Reproduction NOEL | 810 - 1440 ppm | 25 ppm | 32 - 58 |
| Freshwater Fish Acute $LC_{50}$ | 30 ppb | 1.8 ppb | 17 |
| Fish Reproduction NOEC | 15 - 26 ppb | 0.57 ppb | 26 - 46 |
| Aquatic Invertebrate Acute $LC_{50}$ | 30 ppb | 0.10 ppb | 300 |
| Freshwater Invert. Reproduction NOEC | 15 - 26 ppb | 0.04 ppb | 375 - 650 |
| Estuarine Fish Acute $LC_{50}$ | 30 ppb | 0.96 ppb | 31 |
| Estuarine Fish Reproduction NOEC | 15 - 26 ppb | 0.28 ppb | 54 - 93 |
| Estuarine Invertebrate Acute $LC_{50}$ | 30 ppb | 0.035 ppb | 860 |
| Estuarine Invert. Reproduction NOEC | 15 - 26 ppb | < 0.0046 ppb | > 3300 > 5700 |

**Risk Summary for Maximum Almond Orchard Floor Use**: Chlorpyrifos sprayed twice to soil on almond orchard floor at 4 lbs ai/A yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.028-0.25), subacute (0.61-1.1) and reproduction NOEL (81-140), avian subacute (6.0-11) and reproduction NOEL (32-58), freshwater fish acute (17) and reproduction (26-46), aquatic invertebrate acute (300) and reproduction (375-650), estuarine fish acute (31) and reproduction (54-93), estuarine invertebrate acute (860) and reproduction (>3300->5700).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 59 ppm and whole fish of 41 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Risk Quotients for Pecan Orchard Floor**
**(Soil Broadcast Ground Spray Treatment; 2 lbs ai/A; 5 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 523 - 930 ppm | 102 ppm<br>147 ppm<br>647 ppm | 5.1 - 9.1<br>3.6 - 6.3<br>0.81 - 1.4 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 58 - 523 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.57 - 5.1<br>0.39 - 3.6<br>0.09 - 0.81 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 58 - 532 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.13 - 1.1<br>0.9 - 0.81<br>0.018 - 0.16 |
| Mammalian Subacute Dietary $LC_{50}$ | 58 - 930 ppm | 1330 ppm | 0.044 - 0.7 |
| Mammalian Reproduction NOEL | 58 - 930 ppm | 10 ppm | 58 - 93 |
| Avian Subacute Dietary $LC_{50}$ | 58 - 930 ppm | 136 ppm | 0.43 - 6.8 |
| Avian Reproduction NOEL | 58 - 930 ppm | 25 ppm | 2.3 - 37 |
| Freshwater Fish Acute $LC_{50}$ | 35.7 ppb | 1.8 ppb | 20 |
| Fish Reproduction NOEC | 16.8 - 30.9 ppb | 0.57 ppb | 29 - 54 |
| Aquatic Invertebrate Acute $LC_{50}$ | 35.7 ppb | 0.10 ppb | 360 |
| Freshwater Invert. Reproduction NOEC | 16.8 - 30.9 ppb | 0.04 ppb | 420 - 770 |
| Estuarine Fish Acute $LC_{50}$ | 35.7 ppb | 0.96 ppb | 37 |
| Estuarine Fish Reproduction NOEC | 16.8 - 30.9 ppb | 0.28 ppb | 60 - 110 |
| Estuarine Invertebrate Acute $LC_{50}$ | 35.7 ppb | 0.035 ppb | 1000 |
| Estuarine Invert. Reproduction NOEC | 16.8 - 30.9 ppb | < 0.0046 ppb | > 3700 > 7700 |

**Risk Summary for Maximum Pecan Orchard Floor Use**: Chlorpyrifos sprayed five times to soil on a pecan orchard floor at 2 lbs ai/A yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.018-9.1), subacute (0.044-0.7) and reproduction NOEL (58-93), avian subacute (0.43-6.8) and reproduction NOEL (2.3-37), freshwater fish acute (20) and reproduction (29-54), aquatic invertebrate acute (360) and reproduction (420-770), estuarine fish acute (37) and reproduction (60-110), estuarine invertebrate acute (1000) and reproduction (>3700->7700).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of

66 ppm and whole fish of 46 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

### (vii) Cattle Ear Tags and Turkey Pens

**Cattle Ear Tag Uses**: Chlorpyrifos impregnated ear tags (5 percent a.i.) are used on cattle. The volume and frequency of chlorpyrifos use for cattle ear tags is unavailable. Wildlife risks have not been assessed for the use of cattle ear tags. Leaching rates are unknown, consequently the estimation of terrestrial and aquatic EECs and risks have not been assessed.

**Turkey Pen Spray Uses**: Directions for chlorpyrifos use on outdoor turkey pens is a spray treatment. Soils in outdoor turkey pens may be sprayed twice at 4 lbs ai/A at a minimum 28-day, retreatment interval. Soil is sprayed before turkeys are transferred to the pens. Direct application to turkeys is prohibited. The following table shows risk quotients for turkey pen applications, assuming there is vegetation on the floor of the pens.

**Risk Quotients for Treated Turkey Pens**
**(Foliar Spray; 4 lbs ai/A; 2 Applications; 28-Day Interval)**
**(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 574 - 1020 ppm | 102 ppm<br>147 ppm<br>647 ppm | 5.6 - 10<br>3.9 - 6.9<br>0.89- 1.6 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 64 - 574 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.63 - 5.6<br>0.44 - 3.9<br>0.10 - 0.89 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 64 - 574 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.14 - 1.2<br>0.10 - 0.89<br>0.020- 0.18 |
| Mammalian Subacute Dietary $LC_{50}$ | 574 - 1020 ppm | 1330 ppm | 0.43 - 0.77 |
| Mammalian Reproduction NOEL | 574 - 1020 ppm | 10 ppm | 57 - 100 |
| Avian Subacute Dietary $LC_{50}$ | 574 - 1020 ppm | 136 ppm | 4.2 - 7.5 |
| Avian Reproduction NOEL | 574 - 1020 ppm | 25 ppm | 23 - 41 |
| Freshwater Fish Acute $LC_{50}$ | 28.9 ppb | 1.8 ppb | 16 |
| Fish Reproduction NOEC | 14 - 25.2 ppb | 0.57 ppb | 25 - 44 |
| Aquatic Invertebrate Acute $LC_{50}$ | 28.9 ppb | 0.10 ppb | 290 |
| Freshwater Invert. Reproduction NOEC | 14 - 25.2 ppb | 0.04 ppb | 350 - 630 |
| Estuarine Fish Acute $LC_{50}$ | 28.9 ppb | 0.96 ppb | 30 |
| Estuarine Fish Reproduction NOEC | 14 - 25.2 ppb | 0.28 ppb | 50 - 90 |
| Estuarine Invertebrate Acute $LC_{50}$ | 28.9 ppb | 0.035 ppb | 830 |
| Estuarine Invert. Reproduction NOEC | 14 - 25.2 ppb | < 0.0046 ppb | >3000 > 5500 |
| Estuarine Algae Acute $EC_{50}$ | 28.9 ppb | 140 ppb | 0.21 |

**Risk Summary for Turkey Pen Uses**: Risk quotients for chlorpyrifos sprayed twice in outdoor turkey pens exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.02-10), subacute (0.43-0.77), and reproduction NOEL (57-100), avian subacute (4.2-7.5), and reproduction NOEL (23-41), freshwater fish acute (16) and reproduction (25-44), aquatic invertebrate acute (290) and reproduction (350-630), estuarine fish acute (30) and reproduction (50-90), estuarine invertebrate acute (830) and reproduction (>3000->5500), and estuarine algae (0.21).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 55 ppm and whole fish of 38 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

### (viii) Commercial and Residential Uses (Christmas Tree Farms, Ornamentals (Nursery/landscape), Homeowners (Fruit/Nut and Citrus Trees), Golf Courses (turf), Lawn Care, and Residential Perimeter Pest Control)

According to BEAD, non-agricultural, outdoor treatments with chlorpyrifos total about 3,425,000 lbs a.i., excluding termite uses. These sites can be treated by certified applicators (PCOs) and non-certified individuals, such as homeowners. Additional details are not given for the various uses, hence quantification of chlorpyrifos volumes are addressed below.

**Christmas Tree Foliar Spray Uses**: Directions for chlorpyrifos use on Christmas trees of various species in nurseries and plantations on registered labels include aerial sprays twice at 1 lb ai/A or applied as a cut stump drench at 3 lbs ai/100 gallons. Use on tree plantations is limited to Connecticut, Maine, Maryland, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, Washington, and Wisconsin. The following table shows risk quotients for Christmas tree uses.

**Risk Quotients for Christmas Tree Plantations**
**(Foliar Spray; 1 lb ai/A; 2 Applications; 7-Day Interval)**
**(Terrestrial EEC's Based on Fate Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams) | 203 - 360 ppm | 102 ppm | 2.0 - 3.5 |
| (35 grams) | | 147 ppm | 1.4 - 2.4 |
| (1000 grams) | | 647 ppm | 0.31 - 0.56 |
| Mammalian Insectivores $LD_{50}$ (15 grams) | 23 - 203 ppm | 102 ppm | 0.23 - 2.0 |
| (35 grams) | | 147 ppm | 0.16 - 1.4 |
| (1000 grams) | | 647 ppm | 0.036- 0.31 |
| Mammalian Granivores $LD_{50}$ (15 grams) | 23 - 203 ppm | 462 ppm | 0.050- 0.44 |
| (35 grams) | | 647 ppm | 0.036- 0.31 |
| (1000 grams) | | 3233 ppm | 0.007- 0.063 |

| | | | |
|---|---|---|---|
| Mammalian Subacute Dietary $LC_{50}$ | 203 - 360 ppm | 1330 ppm | 0.15 - 0.27 |
| Mammalian Reproduction NOEL | 203 - 360 ppm | 10 ppm | 20 - 36 |
| Avian Subacute Dietary $LC_{50}$ | 203 - 360 ppm | 136 ppm | 1.5 - 2.6 |
| Avian Reproduction NOEL | 203 - 360 ppm | 25 ppm | 8.1 - 14 |
| Freshwater Fish Acute $LC_{50}$ | 11 ppb | 1.8 ppb | 6.1 |
| Fish Reproduction NOEC | 5.4- 10 ppb | 0.57 ppb | 9.5 - 18 |
| Aquatic Invertebrate Acute $LC_{50}$ | 11 ppb | 0.10 ppb | 110 |
| Freshwater Invert. Reproduction NOEC | 5.4- 10 ppb | 0.04 ppb | 135 - 250 |
| Estuarine Fish Acute $LC_{50}$ | 11 ppb | 0.96 ppb | 11 |
| Estuarine Fish Reproduction NOEC | 5.4- 10 ppb | 0.28 ppb | 19 - 36 |
| Estuarine Invertebrate Acute $LC_{50}$ | 11 ppb | 0.035 ppb | 310 |
| Estuarine Invert. Reproduction NOEC | 5.4- 10 ppb | < 0.0046 ppb | >1200 > 2200 |
| Estuarine Algae Acute $EC_{50}$ | 11 ppb | 140 ppb | 0.079 |

**Risk Summary for Maximum Christmas Tree Spray Uses**: Chlorpyrifos aerially sprayed on Christmas trees in plantations yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.007-3.5), subacute (0.15-0.27) and reproduction NOEL (20-36); avian dietary (1.5-2.6) and reproduction NOEL (8.1-14), freshwater fish acute (6.1) and reproduction (9.5-18), aquatic invertebrate acute (110) and reproduction (135-250), estuarine fish acute (11) and reproduction (19-36), estuarine invertebrate acute (310) and reproduction (>1200->2200), and estuarine algae (0.079).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 31 ppm and whole fish of 15 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm.

**Christmas Tree Stump Drench Uses**: Directions for chlorpyrifos use on tree stumps on registered labels include chlorpyrifos applied as a cut stump drench at 3 lbs ai/100 gallons. Description of use rates such as "drench" and "apply to runoff" pose a problem for quantifying terrestrial and aquatic EECs for vegetation, insects, etc. According to these use instructions, the treatment concentration may be as high as 3,595 ppm (i.e., 3 lbs/gallon x 119,830 / 100 gal. = 3,595 ppm).

Wildlife exposures to chlorpyrifos-treated tree stumps may occur in several ways. Some bird species or small mammals may feed on drenched vegetation, seeds or invertebrates, or will drink the runoff from treated stumps or small puddles, or will bathe in the runoff. Birds may also ingest a pesticide when they preen their feathers after bathing in a puddle or brushing against wet

vegetation.

Acute risks to terrestrial wildlife can be estimated using a non-standard risk methodology by calculating how many milliliters of spray are equivalent to the LD50 values. A solution of 3,595 ppm is equivalent to 3.6 mg of chlorpyrifos per ml. Toxic levels (ml or drops per species) can be determined from the LD50 values and body weights of wildlife species. For example, a 0.0277 kg house sparrow with an acute LD50 value of 10 mg/kg has a median lethal dose of 0.277 mg, which yields a risk quotient of 13 for drinking one milliliter of the 3.6 ppm spray solution. Expressed in another way, 1 ml of the 3,595 ppm spray solution of chlorpyrifos contains the equivalent of 13 LD50 doses (RQs) for house sparrows. Given the pharmaceutical measure of about 20 drops per milliliter (verified by the weight measurement of one and ten drops from an eye dropper by laboratory personnel at the Patuxent Wildlife Laboratory, Maryland), 3.6 mg of chlorpyrifos in 1 ml equals 0.18 mg per drop of water. The following table estimates risk quotients for select avian and mammalian species drinking one drop of the spray solution.

**Wildlife Risks from Tree Stump Drench Use Expressed as Number of Water Drops per $LD_{50}$ and Risk Quotients per Drop**
(1 ml of 3,595 ppm solution equals 0.18 mg/drop)

| Species | $LD_{50}$ | Body Wt. (kg) | $mg/LD_{50}$ | Water Drops/$LD_{50}$[a] | Risk Quotient/Drop |
|---|---|---|---|---|---|
| House Sparrow | 10 | 0.0277 | 0.277 | 1.5 | 0.65 |
| Mammal (35 grams body wt.) | 97 | 0.035 | 3.395 | 19 | 0.053[b] |
| Rat | 97 | 0.200 | 19.4 | 110 | 0.009 |
| Cockerel | 34.8 | 1.500 | 52.20 | 290 | 0.003[c] |
| Mallard Duck | 75.6 | 1.082 | 81.80 | 450 | 0.002[d] |

[a] One tablespoon is equivalent to about 296 drops.
[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 5.3 based on drinking only from the spray runoff for one day.
[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 12 based on drinking only from the spray runoff for one day.
[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 18 based on 300 ml of water consumed in one day.

**Risk Summary for Christmas Tree Stump Drench Uses**: Non-standard, risk quotients for wildlife drinking a single drop of the 3,595 ppm spray on drenched tree stumps exceeds levels of concern for several non-target terrestrial animals. Few species drink only one drop when they drink or are thirsty. A one-time consumption equivalent to one tablespoon (296 drops) is not unreasonable for most middle-sized wildlife species. Risk quotients for the least sensitive species at the bottom of the table are high (RQ = 12 for chickens and 18 for mallard ducks), if they consume the spray at normal water levels for one day. The $LD_{50}$ value for a 1,000 gram mammal is the equivalent of drinking one (1) ounce of the 3,595 ppm spray solution (540 drops / 20 drops/ml / 28.35 grams/ounce = 0.95 ounces). For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that the spray treatment of the stump may pose acute risks to aquatic organisms, if rainfall washed the spray solution off the tree stumps into an adjacent aquatic areas.

**Nursery Ornamental Uses**: Nursery ornamentals may be sprayed broadcast or applied to foliage until the spray runs off with large tank sprayers or compressed air sprayers. Application rates with large tank sprayers are typically applied once or twice at 0.25-0.5 lbs ai/100 gallons. Aerial applications are not permitted in nurseries.

A non-standard, risk methodology for drinking exposures assessed above for tree stumps uses, can also be used to assess terrestrial wildlife risks for ornamental uses. The maximum registered use rate on ornamentals is 0.5 lbs ai/A or one-sixth the rate for tree stumps. Consequently the terrestrial risk quotients are one-sixth the values in the above table.

While the level of risks are reduced, the risk quotient for the house sparrow exceeds the level of concern for acute toxicity for endangered species for consumption of a single drop. Normal water consumption rates of a few to many drops, would increase the number of wildlife species that exceed levels of concern. Aquatic risks have not been assessed, based on these use rates.

Monitoring data from the San Diego Creek and the Upper Newport Bay watershed in southern California are reported by G. Fred Lee & Associates (Unpublished letter dated January 29,1999). The report shows frequent water samples with chlorpyrifos concentrations which exceed the toxicity levels for both *Ceriodaphnia* (80 ng/L) and *Mysidopsis* (35 ng/L). The example given for the San Diego Creek reported 430 ng/L chlorpyrifos and the presence of several other pesticides. The Upper Newport Bay watershed has substantial residential, vegetable agriculture and several commercial nurseries. The letter states “We are finding a variety of pesticides in our samples, some of which seem to be associated with their use at commercial nurseries.” Out of the 48 water samples collected between October 30, 1996 and August 25, 1998, 16 samples (33 %) exceed the toxicity level for *Ceriodaphnia* and 25 samples (52 %) exceed the toxicity value for *Mysidopsis*. On two occasions, chlorpyrifos concentrations were sufficiently high to produce toxic effects to fathead minnow larvae (Santa Ana Delhi Channel on March 1998 and Hines channel at Irvine Creek Drive in August 1998). The later sampling site is located just downstream from two large commercial nurseries.

**Homeowner Ornamental Uses**: Directions for homeowner use on ornamentals on registered labels permits chlorpyrifos to be sprayed with a 1.7% to 12% concentrate diluted with 15 to 30 gallons of water in hose-end sprayers. Ornamentals are sprayed to runoff. Description of use rates as "apply to runoff" is not quantifiable and poses a problem for calculating EECs. According to available label instructions, treatment concentrations may be 8,000 ppm (i.e., 120,000 ppm / 15 gallons = 8,000 ppm). Dow (1999 comments) indicated that the highest orchard use is 10,000 ppm for beetle control. The following table estimates the number of spray drops equal to the $LD_{50}$ values and non-standard, risk quotients for select avian and mammalian species drinking one (1) drop of the 8,000 ppm spray solution.

**Wildlife Risks from Ornamental Uses Expressed as Number of Water Drops per $LD_{50}$ and Risk Quotients per Drop**
12% Concentrate in 15 Gallons of water (1 ml of 8,000 ppm solution equals 0.4 mg/drop)

| Species | $LD_{50}$ | Body Wt. (kg) | mg/$LD_{50}$ | Water Drops/$LD_{50}$[a] | Risk Quotient/Drop |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| House Sparrow | 10 | 0.0277 | 0.277 | 0.69 | 1.4 |
| Mammal (35 grams body wt.) | 97 | 0.035 | 3.395 | 8.5 | 0.12[b] |
| Rat | 97 | 0.200 | 19.4 | 48.5 | 0.021 |
| Cockerel | 34.8 | 1.500 | 52.20 | 130 | 0.0077[c] |
| Mallard Duck | 75.6 | 1.082 | 81.80 | 204 | 0.0049[d] |

[a] One tablespoon is equivalent to about 296 drops.

[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 12 based on drinking only from the spray runoff for one day.

[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 30 based on drinking only the spray runoff for one day.

[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 25 based on 300 ml of water consumed in one day.

**Risk Summary for Maximum Homeowner Ornamental Uses**: The 8,000 ppm aqueous spray exceeds the levels of concern for some terrestrial animals based on the consumption of only one drop. A one-time consumption equivalent to one tablespoon (296 drops) is not unreasonable for most middle-sized animal species. The footnotes for cockerels and mallard ducks suggest possible risks to these and other large species based on a single day's consumption of water. For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that the spray treatment of ornamentals to runoff is likely to pose acute risks to aquatic organisms, if rainfall washes the spray solution off the ornamentals and the application runoff into an adjacent aquatic areas. The maximum use rate at 10,000 ppm would yield even higher risks to terrestrial and aquatic species, than the 8,000 ppm treatment. Dow states that the vast majority of ornamental uses are applied at 600 to 1200 ppm.

**Homeowner Fruit Tree Uses**: Directions for chlorpyrifos use on fruit trees on registered labels are as follows. Homeowner use on fruit, nut, and citrus trees are sprayed at 0.25-2 lbs ai/100 gallons (1-4 lbs ai/A). Residential orchards are likely to be considerably less than the 10-hectare area assumed in the GENEEC model and the presence of a 1-hectare pond on the edge of the orchard is unlikely. Runoff into streams and ditches is much more likely than into ponds. Since a model is not available for flowing waters, only terrestrial risks have been assessed for this use. The following table shows risk quotients for terrestrial species for use on residential fruit trees.

**Risk Quotients for Homeowner Fruit, Nut and Citrus Trees**
**(Ground Spray Treatment; 4 lbs ai/A; 1 Application)**
**(Terrestrial EEC's Based on Nomograph)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.) | 540 - 960 ppm | 102 ppm | 5.3 - 9.4 |
| (35 grams body wt.) | | 147 ppm | 3.7 - 6.5 |
| (1000 grams body wt.) | | 647 ppm | 0.83- 1.5 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.) | 60 - 540 ppm | 102 ppm | 0.59 - 5.3 |
| (35 grams body wt.) | | 147 ppm | 0.41 - 3.7 |
| (1000 grams body wt.) | | 647 ppm | 0.093- 0.83 |

| | | | |
|---|---|---|---|
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 60 - 540 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.13 - 1.2<br>0.093- 0.83<br>0.019- 0.17 |
| Mammalian Subacute Dietary $LC_{50}$ | 540 - 960 ppm | 1330 ppm | 0.41 - 0.72 |
| Mammalian Reproduction NOEL | 540 - 960 ppm | 10 ppm | 54 - 96 |
| Avian Subacute Dietary $LC_{50}$ | 540 - 960 ppm | 136 ppm | 4.0 - 7.1 |
| Avian Reproduction NOEL | 540 - 960 ppm | 25 ppm | 22 - 38 |

**Risk Summary for Homeowner Fruit Tree Uses**: Chlorpyrifos sprayed twice to soil on almond orchard floor at 4 lbs ai/A yields risk quotients which exceed the levels of concern for most terrestrial animals. Risk quotients are mammalian acute (0.019-9.4), subacute (0.41-0.72) and reproduction NOEL (54-96), avian subacute (4.0-7.1) and reproduction NOEL (22-38). Residential areas using chlorpyrifos are relatively small compared to the assumption of 10-treated hectares around a 1-hectare pond. Hence risk quotients are less than would be predicted by the GENEEC model, because of the small acreage.

**Maximum Applications on Golf Course Turf**: The volume of chlorpyrifos applied nationally on golf course turf and typical use rates have not been reported. Directions for chlorpyrifos use on golf course turf include spray and granular formulations. The application rate, number of applications and interval between applications are the same as those used in a field study on golf courses in Central Florida. The use in the Florida field study was supposed to represent the maximum seasonal use rates. Risk quotients estimated in the following two tables assume maximum application rates of chlorpyrifos on golf course turf. For spray applications, Dursban 50W Nursery is labeled for a 4 lbs ai/A application to control white grubs, but the label does not indicate a limit on the number of applications or provide a retreatment interval for control of white grubs. The only retreatment interval cited on the label for turf is 1 to 2 weeks for a 2 lbs ai/A use to control the adult form of one white grub species (i.e., black turfgrass ataenius adults). EFED assumed a 30-day retreatment interval for the spray use, since the label specifies no use limit and a Florida golf course field study cites 21 days as the minimum treatment interval. The same use rate and retreatment interval was assessed for granular treatment of golf courses based on the use pattern Dow tested on the Florida golf course field study.

**Risk Quotients for Maximum Golf Course Turf Use**
**(Ground Spray Treatment; 4 lbs ai/A; 2 Applications; 30-Day Interval)**
**(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 568 - 1,009 ppm | 102 ppm<br>147 ppm<br>647 ppm | 5.6 - 9.9<br>3.9 - 6.9<br>0.88 - 1.6 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 63 - 568 ppm | 102 ppm<br>147 ppm<br>647 ppm | 0.62 - 5.6<br>0.43 - 3.9<br>0.097 - 0.88 |

| | | | |
|---|---|---|---|
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 63 - 568 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.14 - 1.2<br>0.097 - 0.88<br>0.019 - 0.18 |
| Mammalian Subacute Dietary $LC_{50}$ | 568 - 1,009 ppm | 1330 ppm | 0.43 - 0.76 |
| Mammalian Reproduction NOEL | 568 - 1,009 ppm | 10 ppm | 57 - 100 |
| Avian Subacute Dietary $LC_{50}$ | 568 - 1,009 ppm | 136 ppm | 4.2 - 7.4 |
| Avian Reproduction NOEL | 568 - 1,009 ppm | 25 ppm | 23 - 58 |
| Freshwater Fish Acute $LC_{50}$ | 29 ppb | 1.8 ppb | 16 |
| Fish Reproduction NOEC | 14.6 - 25.5 ppb | 0.57 ppb | 26 - 45 |
| Aquatic Invertebrate Acute $LC_{50}$ | 29 ppb | 0.10 ppb | 290 |
| Freshwater Invert. Reproduction NOEC | 14.6 - 25.5 ppb | 0.04 ppb | 370 - 640 |
| Estuarine Fish Acute $LC_{50}$ | 29 ppb | 0.96 ppb | 30 |
| Estuarine Fish Reproduction NOEC | 14.6 - 25.5 ppb | 0.28 ppb | 52 - 91 |
| Estuarine Invertebrate Acute $LC_{50}$ | 29 ppb | 0.035 ppb | 830 |
| Estuarine Invert. Reproduction NOEC | 15.6 - 25.5 ppb | < 0.0046 ppb | > 3200 > 5500 |
| Estuarine Algae $EC_{50}$ | 29 ppb | 140 ppb | 0.21 |

**Risk Summary for Maximum Golf Course Spray Treatments Uses**: Chlorpyrifos sprayed twice at a one-month interval at 4 lbs ai/A yields risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.097-9.9), subacute (0.43-0.76) and reproductive NOEL (57-100), avian subacute (4.2-7.4) and reproductive NOEL (23-58), freshwater fish acute (16) and reproductive NOEC (26-456), aquatic invertebrate acute (290) and reproductive NOEC (370-640), estuarine fish acute (30) and reproductive NOEC (52-91), estuarine invertebrate acute (830) and reproductive NOEC (>3200->5500), and estuarine algae (0.21). The above aquatic risk quotients for golf course turf uses may be too high, because the GENEEC Model does not include reduced runoff due to ground cover. However, risks to aquatic species do exist as indicated by several fish kills that were found in water hazards and a pond adjacent to treated turf areas during a central Florida golf course field study.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 57 ppm and whole fish of 40 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than avian reproductive NOEL of 25 ppm.

**Granular Risk Quotients for Golf Course Turf**
**(Soil Broadcast, Unincorporated; 4 lbs ai/A; 2 Applications, 30-Day Interval)**
**(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)**

| Species | Toxicity | Exposure | Toxicity Dose | Risk Quotient |
|---|---|---|---|---|
| Mammalian Acute $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 97 mg/kg | 41.7 mg/ft$^2$* | 1.5 mg<br>3.4 mg<br>97 mg | 28<br>12<br>0.43 |
| Avian Acute Oral $LD_{50}$ (27.7 grams body wt.) | 10 mg/kg | 41.7 mg/ft$^2$* | 0.28 mg | 150 |
| Freshwater Fish Acute $LC_{50}$ | 1.8 ppb | 25.3 ppb | | 14 |
| Fish Reproduction NOEC | 0.57 ppb | 12.8 - 22 ppb | | 22 - 39 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.10 ppb | 25.3 ppb | | 250 |
| Freshwater Invert. Reproduction NOEC | 0.04 ppb | 12.8 - 22 ppb | | 320 - 550 |
| Estuarine Fish Acute $LC_{50}$ | 0.96 ppb | 25.3 ppb | | 26 |
| Estuarine Fish Reproduction NOEC | 0.28 ppb | 12.8 - 22 ppb | | 46 - 79 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.035 ppb | 25.3 ppb | | 720 |
| Estuarine Invert. Reproduction NOEC | < 0.0046 ppb | 12.8 - 22 ppb | | >2800 >4800 |
| Estuarine Algae $EC_{50}$ | 140 ppb | 25.3 ppb | | 0.18 |

* mg ai/foot$^2$ = $\frac{4.0 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2}$ = 41.7 mg/ft$^2$

**Risk Summary for Maximum Golf Course Granular Treatments Uses**: Chlorpyrifos granules broadcast on golf course turf at 4 lbs ai/A twice at a one-month interval yield risk quotients which exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.43-28); avian acute (150); freshwater fish acute (14) and reproductive NOEC (22-39), aquatic invertebrate acute (250) and reproductive NOEC (320-550), estuarine fish acute (26) and reproductive NOEC (46-79), estuarine invertebrate acute (720) and reproductive NOEC (>2800->4800), and estuarine algae (0.18).
Piscivorous mammals are exposed to estimated residues in the fish viscera of 50 ppm and whole fish of 35 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm but more than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm but more than the avian reproductive NOEL of 25 ppm. Again, the aquatic risk quotients may be a little too high, because the GENEEC Model does not incorporate reductions in runoff due to ground cover. However, in a central Florida golf course field study, acutely lethal, chlorpyrifos residues were measure in water in two out of four treated areas on Day 0 (1.69 and 2.55 ppb on replicates G5 and G8, respectively). On several occasions during the field study, dead fish were found in water hazards and a pond adjacent to treated turf areas.

**Comparison of Formulation Risks for Maximum Golf Course Uses**: Comparison of risk quotients for spray and granular applications on golf course turf at the same use rates suggest that the granular formulation is more acutely toxic to birds, mammals and other terrestrial species, while the spray formulation is only slightly more toxic to aquatic species.

**Golf Course Field Study in Central Florida**: In a Central Florida golf course field study, chlorpyrifos was applied at 4 lbs ai/A per treatment on four replicates. The two chlorpyrifos formulations studied were Dursban Turf Insecticide (a liquid spray formulation) or with Dursban 2.5 Granular Insecticide. Four additional golf courses were used as controls. Two treatments were applied to each replicate golf course during the summer of 1992 at a minimum interval of 21 days between treatments. The golf courses ranged from 50 to 250 acres with treatment areas ranging from 4.7 to 7.2 acres.

Chlorpyrifos levels were measured in various environmental samples (i.e., soil and water samples). The soil sample was a core of grass, thatch and 10 cm of soil. Residues on treated grass alone were not measured. Residue measurements are summarized in the tables below for liquid and granular treatments.

| CHLORPYRIFOS RESIDUES ON GOLF COURSES SPRAYED AT 4 LBS AI/A | | | | |
|---|---|---|---|---|
| Substrate (1st & 2nd Appl.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EFED Estimated Initial Conc. [a] |
| 1st Soil (10 cm) | 1.57 ppm | 1.42-1.75 ppm | 2.3 ppm | 2.2 ppm |
| 2nd Soil (10 cm) | 2.21 ppm | 1.50-3.50 ppm | 3.5 ppm | 2.48 ppm |
| 1st Water (ppb) | < 1.0 ppb | not detected | < 1.0 ppb | 14.75 ppb |
| 2nd Water (ppb) | < 1.0 ppb | not detected | < 1.0 ppb | 29.03 ppb |

[a] Chlorpyrifos level is assumed to be uniformally dispersed to a 4-inch depth to conform to the sampling depth.

| CHLORPYRIFOS RESIDUES ON GRANULAR-TREATED GOLF COURSES APPLIED AT 4 LBS AI/A | | | | |
|---|---|---|---|---|
| Substrate (1st & 2nd Appl.) | Initial Mean Conc. | Initial Mean Ranges | Highest Conc. | EFED Estimated Initial Conc. [a] |
| 1st Soil (10 cm) | 2.83 ppm | 1.10- 6.86 ppm | 16.8 ppm | 2.2 ppm |
| 2nd Soil (10 cm) | 4.41 ppm | 1.60- 9.37 ppm | 15.2 ppm | 2.45 ppm |
| 1st Water (ppb) | < 1.0 ppb | not detected | < 1.0 ppb | 13.28 ppb |
| 2nd Water (ppb) | 0.905 ppb | n.d.-1.52 ppb | 2.55 ppb | 25.31 ppb |

[a] Chlorpyrifos level is assumed to be uniformally dispersed to a 4-inch depth to conform to the sampling depth.

Comparison of measured residues reported in the field study to EFED estimated exposures in the above tables shows that measured chlorpyrifos residue levels in soils are similar to levels estimated for the same depth of soil. Measured residues in water were consistently lower than predicted EECs in water. The mean residue levels of chlorpyrifos in soil were measured in the top 10 cm of soil. EFED suggests that measuring chlorpyrifos residues in soil to a depth on 10 cm immediately after application underestimates exposures the wildlife. It is expected that immediately after application, chlorpyrifos would be found in about the upper 1 cm of soil, until rainfall and/or watering leaches the chlorpyrifos residues deeper. Thus it is concluded that the reported, initial residue levels in soil underestimate soil concentrations and exposures by about 10 fold. Normally, the Agency does not use soil residue levels in terrestrial risk assessments, unless information is available that indicates that the pesticide bioconcentrates in soil organisms. At least slight bioaccumulation of chlorpyrifos in soil organisms might be expected, but soil bioaccumulation data are unavailable and therefore, not estimated in this risk assessment. The usual terrestrial exposure assessments estimate the "highest or upper level" EECs on vegetation, insects, fruits and seeds. In this field study, residue levels on turf were not measured. Hence, terrestrial EECs used in this risk assessment can not be confirmed or denied. Some wildlife species utilizing golf courses can be expected to feed on grasses, insects, earthworms, etc. Since the Agency assesses terrestrial risks for residues on grass, the turf/soil samples measured in this study are not comparable to EECs assessed in EFED risk assessments.

Comparison of predicted aquatic EECs and measured chlorpyrifos residues in the turf field study, indicates that measured levels are consistently less than EECs used in the risk assessment for golf courses. It is acknowledged that the GENEEC Model may overestimate aquatic EECs when ground cover is present on treated areas. Also, prediction of aquatic ECCs is highly problematic for reasons discussed in the above corn and citrus field studies. In the Tampa area, the annual rainfall is approximately 124.5 cm, sixty percent of which occurs between June and September in the form of localized afternoon thunderstorms. Rainfall during the study period from late summer to early fall was lower than the long-term average during the same period. The treatment areas were spread over three counties (5 in Pinellas County, 5 in Hillsborough County and 2 in Pasco County), which accounts for the differences in rainfall levels among the replicates.

Out of sixteen water samples from aquatic areas adjacent to treated turf, only two samples exceeded the level of detection of 1 ppb (i.e., 1.69 and 2.55 ppb). Both water samples with measurable levels of chlorpyrifos were found in aquatic areas adjacent to granular-treated areas. The level of detection for water (1 ppb) is greater than the acute aquatic invertebrate $EC_{50}$ values (i.e., 0.1 and 0.035 ppb), therefore the risk to aquatic invertebrates can not be assessed for most aquatic areas. Researchers reported finding dead fish on several occasions during the field study in water hazards and a pond adjacent to treated areas.

**Wildlife Mortality and Sublethal Observations**: Results from a central Florida, golf course field study confirmed risks to terrestrial wildlife and aquatic organisms. Carcasses searches were made prior to each application to remove all dead animals. Transacts totalled 2400 m on each replicate with 1800 m along the turf perimeter and 600 m in the adjacent habitat. Approximately two hours were spent searching each replicate per sampling day. Evaluation of carcass removal

indicates that overall, 50 % of the carcasses were removed or hidden by scavengers by the second day and 99 percent were removed by Day 4. Removal rates were similar between treatment groups. Wildlife carcasses were placed on the golf courses for detectability trials. Recovery rates were 90 % on the fairway, 83 % in the rough, and 31 % in the adjacent habitat. Overall recovery rates were 77 %, 68 % and 69 % for liquid treatments, granular treatments and reference replicates, respectively.

Results from wildlife censuses, collection of casualties and chlorpyrifos analyses of carcasses are summarized in the table below. Casualty levels found on the reference replicates is inflated as a result of extra casualties found during the increased amount of time spent conducting additional activities on reference replicates.

Out of the 26 carcasses collected during the field study, only six carcasses were analyzed. Two of those six carcasses showed the presence of chlorpyrifos residues and two animals (i.e., a double-crested cormorant and a southern toad) showed cholinesterase behavior, but were negative for chlorpyrifos. A Florida soft-shell turtle contained 1.09 ppm and a ribbon snake carcass contained 15.11 ppm chlorpyrifos. Wildlife utilize areas adjacent to golf courses more than the turf. However, some wildlife species, such as ducks, geese, robins, mockingbirds, etc., feed on grassy areas eating vegetation, insects and/or soil organisms. Historically, a high number of bird kills have been reported on golf courses treated with fast-acting carbofuran and diazinon. Presumably, the reported wildlife kills on golf courses are largely due to the open areas and high human traffic.

It should be noted that during the chlorpyrifos, terrestrial field study on golf courses, some fish kills were observed in aquatic areas adjacent to the chlorpyrifos-treated golf courses. The authors made the following comments in their report. "On several occasions fish were found dead in water hazards during the study, some of which were found in the study area and some which were found outside of the study area on test golf courses. The Sponsor was notified of the occurrence and provided with water, sediment and fish samples. Any fish collected were shipped to the Sponsor for evaluation along with fourteen water samples and twelve sediment samples collected from water hazards where the dead fish were found. Since the study deals with terrestrial hazard and was not structured to evaluate aquatic hazard, the responsibility for reporting these occurrences was left with the Sponsor and are not discussed in this reported." Information on chemical analyses of the samples of fish, sediments, and water have not been received by EPA for review.

**Lawn Care Uses**: Several lawn care products exist, including EC, granular, scattered bait, and fertilizer formulations. The EC formulation may be applied commercially from a large tank sprayer or from a hose-end sprayer (mostly homeowners). Large tank spray applications usually are sprayed once or twice with 1 to 4 gallons/1,000 $ft^2$ (1 lb ai/A) or at 0.125 to 8 lbs ai/A with a 6-week typical minimum retreatment interval. The 8 lbs ai/A use rate is for sod farms to control fire ants and is not for homeowner use (Dursban 50W, 3-03-99). Hose-end sprayer treatments (mostly homeowners) use a 1.7 to 12% concentrate diluted by 10-30 gallons/lawn (as high as 8,000 ppm in water on lawn) (1 lb ai/A typical rate). Dry formulations, such as baits and fertilizer (i.e., 0.5 and 1% granules) are broadcast or spread by drop spreader at 1-2 lbs ai/A (typical use is

1 lb ai/A with 1 or 2 applications with a minimum of 6 weeks retreatment interval). Depending on the area, runoff from treated lawns may be more likely to flow into streams than ponds. Since the GENEEC Model reflects aquatic contamination by runoff and soil erosion, it is not a suitable model for grassy areas. Furthermore, most treated lawns are unlikely to cover 10 hectares around a 1-hectare pond. Since the GENEEC Model would yield unrealistic EECs, aquatic EECs have not been estimated. The following 2 tables assess terrestrial risks for lawn care uses of chlorpyrifos.

**Risk Quotients for Moderate Lawn Care Applications**
**(Foliar Spray; 1 lb ai/A; 2 Applications; 42-Day Interval)**
**(Terrestrial EEC's Based on Fate Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.) | 137 - 244 ppm | 102 ppm | 1.3 - 2.4 |
| (35 grams body wt.) | | 147 ppm | 0.93 - 6.9 |
| (1000 grams body wt.) | | 647 ppm | 0.21 - 0.38 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.) | 15 - 137 ppm | 102 ppm | 0.15 - 1.3 |
| (35 grams body wt.) | | 147 ppm | 0.10 - 0.93 |
| (1000 grams body wt.) | | 647 ppm | 0.023- 0.21 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.) | 15 - 137 ppm | 462 ppm | 0.032- 0.30 |
| (35 grams body wt.) | | 647 ppm | 0.023- 0.21 |
| (1000 grams body wt.) | | 3233 ppm | 0.005- 0.042 |
| Mammalian Subacute Dietary $LC_{50}$ | 137 - 244 ppm | 1330 ppm | 0.10 - 0.18 |
| Mammalian Reproduction NOEL | 137 - 244 ppm | 10 ppm | 14 - 24 |
| Avian Subacute Dietary $LC_{50}$ | 137 - 244 ppm | 136 ppm | 1.0 - 1.8 |
| Avian Reproduction NOEL | 137 - 244 ppm | 25 ppm | 5.5 - 9.8 |

**Risk Quotients for Maximum Sod Farm Applications**
**(Foliar Spray; 8 lb ai/A; 2 Applications; 42-Day Interval)**
**(Terrestrial EEC's Based on Fate Model)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.) | 1097 - 1950 ppm | 102 ppm | 11 - 19 |
| (35 grams body wt.) | | 147 ppm | 7.5 - 13 |
| (1000 grams body wt.) | | 647 ppm | 1.7 - 3.0 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.) | 122 - 1097 ppm | 102 ppm | 1.2 - 11 |
| (35 grams body wt.) | | 147 ppm | 0.83- 7.5 |
| (1000 grams body wt.) | | 647 ppm | 0.19- 1.7 |
| Mammalian Granivores $LD_{50}$ (15 grams body wt.) | 122 - 1097 ppm | 462 ppm | 0.26- 2.3 |
| (35 grams body wt.) | | 647 ppm | 0.19- 1.7 |
| (1000 grams body wt.) | | 3233 ppm | 0.04- 0.34 |
| Mammalian Subacute Dietary $LC_{50}$ | 1097 - 1950 ppm | 1330 ppm | 0.82- 1.5 |
| Mammalian Reproduction NOEL | 1097 - 1950 ppm | 10 ppm | 110 - 2000 |
| Avian Subacute Dietary $LC_{50}$ | 1097 - 1950 ppm | 136 ppm | 8.1 - 14 |
| Avian Reproduction NOEL | 1097 - 1950 ppm | 25 ppm | 44 - 78 |

**Risk Summary for Moderate and Maximum Lawn Care and Sod Uses**: Risk quotients for chlorpyrifos sprayed twice for lawn care at 1 lb ai/A exceed the levels of concern for most non-target terrestrial animals. Risk quotients are mammalian acute (0.071-2.4), subacute (0.10-0.18), and reproduction NOEL (14-24), avian subacute (1.0-1.8), and reproduction NOEL (5.5-9.8). Aquatic exposures and risk quotients were not determined.

Risk quotients for chlorpyrifos sprayed twice on sod at sod farms at 8 lbs ai/A exceed the levels of concern for most wildlife categories. Risk quotients are mammalian acute (0.04-19), subacute (0.82-1.5), and reproduction NOEL (110-2000), and avian subacute (8.1-14), and reproduction NOEL (44-78). Aquatic exposures and risk quotients were not determined.

**Residential Perimeter Uses**: Directions for chlorpyrifos use on residential perimeter pest control on registered labels include liquid sprays, dusts, granules, and a micro-encapsulated liquid suspension. The Dursban 1-12 label permits several spray applications around homes. Outside surfaces of buildings maybe sprayed with chlorpyrifos at 5,250 ppm to control a large number of common insects, mites, ticks and spiders and to control wood-infesting insects. A perimeter band treatment 6 to 10 feet wide around a structure may be sprayed at 325 ppm. Lawns and other outside uses, such as trails, picnic and camping sites can be sprayed at levels ranging from 3 to 12 fl. oz./1,000 sq. ft. (i.e., 3.8 to 22.7 ppb). Aquatic risks have not been assessed for this use, because the GENEEC Model does not allow for reduced erosion from grassy areas or the relatively small treated areas around structures compared to 10 hectares surrounding a 1-hectare pond.

Residential pest control applications are assessed for risks in the following table which estimates the number of spray drops equal to the $LD_{50}$ values and the risk quotients for select avian and mammalian species drinking one (1) drop of the spray solution. It is evident that species listed in the table below are capable of drinking more than a single drop off leaves and other vegetation.

**Risks from Maximum Residential Pest Use Expressed as Number of Water Drops per $LD_{50}$ and Risk Quotients per Drop (1 ml of 5,250 ppm solution equals 0.26 mg/drop)**

| Species | $LD_{50}$ | Body Wt. (kg) | mg/$LD_{50}$ | Water Drops/$LD_{50}$[a] | Risk Quotient/Drop |
|---|---|---|---|---|---|
| House Sparrow | 10 | 0.0277 | 0.277 | 1.1 | 0.94 |
| Mammal (35 grams body wt.) | 97 | 0.035 | 3.395 | 13 | 0.077[b] |
| Rat | 97 | 0.200 | 19.4 | 75 | 0.013 |
| Cockerel | 34.8 | 1.500 | 52.20 | 200 | 0.0050[c] |
| Mallard Duck | 75.6 | 1.082 | 81.80 | 310 | 0.0032[d] |

[a] One tablespoon is equivalent to about 296 drops.

[b] A 0.025 kg mouse consumes 5 ml of water per day, which yields a RQ of about 18 based on drinking only from the spray runoff for one day.

[c] A 0.8 kg adult chicken consumes 200 ml of water per day, which yields a RQ of about 44 based on drinking only the spray runoff for one day.

[d] A 2.5 kg adult domestic duck consumes about 500 ml of water per day, which yields an adjusted RQ of about 44 based on 300 ml of water consumed in one day.

**Risk Summary for Maximum Residential Outdoor Pest Uses**: The 5,250 ppm ai aqueous spray applied as a residential perimeter treatment would likely exceed acute levels of concern for at least one terrestrial animal listed in the above table, based only on consumption of a relatively few number of drops to less than one tablespoon (i.e., 290 drops). For aquatic risk assessment, the quantification of EECs in adjacent aquatic habitats poses a complex problem. It is sufficient to say that rainfall may the result in runoff of chlorpyrifos residues applied as a perimeter pest treatment into an adjacent aquatic areas.

### (ix) Termiticide Uses

**Indoor and Foundation Termiticide Uses**: Three chlorpyrifos formulations (i.e., 1.7 EC, 2 EC and 4 EC) are registered for termite control. According to BEAD, the total volume of chlorpyrifos used for termite treatments inside all types of buildings is 2,600,000 lbs ai. Most termite pesticide control operators use 0.75-1 percent solution. Wood insects may be treated with a 0.5-1 percent solution. The typical house treatment involves drilling holes about every 8 inches into the foundation or in the floor about 3 inches from the wall followed by injection of chlorpyrifos. Outside the house, a trench is dug around the outside foundation, the chlorpyrifos solution is sprayed in to the trench as drench, and then the soil is replaced. To prevent seepage along underground water lines or drain lines to wells or aquatic areas, the soil may be removed and the solution mixed into the soil before returning the soil to the fault area. The above described method, if carefully followed should pose little risk to wildlife and aquatic species. Several fish kill incidents have been reported which are associated with indoor termiticide uses.

### (x) Mosquito Adulticide Uses

**Mosquito Larvicide Uses**: Several chlorpyrifos formulations were registered for mosquito larvicide uses with direct application to aquatic areas. Since no chlorpyrifos registrant is supporting the data requirements for the larvicide applications and the mosquito larvicide use has been cancelled from all chlorpyrifos labels. Consequently, there is no need for risks to aquatic and terrestrial animals to be assessed.

**Mosquito Adulticide Uses**: Four chlorpyrifos formulations for mosquito adulticide uses are registered by Clarke Mosquito Control Products, Inc. Mosquitomist One U.L.V., a 13.6 % formulation with 1 lb ai/gallon, makes up about 60 percent of the total sales for adult mosquito use in residential and recreational areas. Mosquitomist One U.L.V. is sprayed either as a thermal fog or as an ultra low volume (ULV) nonthermal aerosol (cold fog) to control adult mosquitoes in residential, recreational, and other non-cropland areas where these insects are a problem. Preferably, applications are made during the cool hours of the night or early morning. Repeat sprayings are made as necessary. For the thermal fog application, 9 gallons are mixed in 91 gallons of No. 2 fuel oil or other fuel, diesel or kerosene-type oil. The mixture is sprayed at a rate of 52.5 gallons per hour at an average vehicle speed of 5 miles per hour to cover a swath of up to 300 feet. For ULV nonthernal aerosol (cold fog) application, applications are sprayed with droplets ranging in size from 5 to 30 microns and a mass median diameter (MMD) of 10 to 15

microns. The rate of application is 0.005 to 0.01 pounds of chlorpyrifos per acre based on an effective swath width of 300 feet. Aerial ULV applications are made at an altitude of 300 feet and at a rate of 0.023 pounds ai/A for an affective swath of 500 feet. Aerial use in Florida requires there be a declared emergency and State approval.

Mosquitomist 1.5 U.L.V., a 19.36 % formulation with 1.5 lbs ai/gallon, makes up about 33 percent of the total sales for mosquito uses. Mosquitomist 1.5 U.L.V. also is for mosquito control in residential and recreational areas with the same uses and application rates as Mosquitomist One U.L.V..

Mosquitomist Two U.L.V., a 24.6 % formulation with 2 lbs ai/gallon, is applied as a ULV spray or diluted with water and applied as a residual foliage spray with ground or aerial equipment only as a ULV nonthermal aerosol (cold fog) application. Ground ULV applications may be made at 0.01-0.024 lbs ai/A. Aerial ULV applications are made at 0.01-0.024 lbs ai/A and residual foliage spray may be applied at 0.024 in light to medium vegetative covered areas and at 0.05 lbs ai/A in medium to heavy vegetative covered areas.

ULV Mosquito Master 412 is a mixture of 12 % chlorpyrifos (90 lbs/gallon of highly refined mineral oil) and 4 % permethrin (30 lbs/gallon) for use by public health officials as well as trained personnel. The formulation is an all temperature, quick knockdown, combination to control adult mosquito populations in residential and recreational areas and also for use against black flies, biting and non-biting midges. It is applied as a ULV nonthermal aerosol (cold fog) application. For ground applications, the mixture may be applied at 0.005 to 0.021 lbs ai/A chlorpyrifos and 0.0017-0.007 lbs ai/A permethrin. Aerial applications may be applied at 3.0 fluid ounces per acre.

UVL and thermal-fog sprays produce a mist intended to remain airborne longer than do the larger droplets produced by standard spray applications. Therefore, EFED's standard assumption of 5 percent deposition from aerial spray applications may be too conservative when estimating how much spray may be directly deposited in a water body. Field studies on ULV applications with various pesticides indicate spray drift to aquatic areas of between 5 to 20 percent (Fenthion RED). Hence the 15 percent spray drift, deposition level used to assess risks is conservative, but it is not worst case. The following table indicates the risk to non-target species from mosquito adulticide ULV use at the maximum use rate and moderately conservative 15% spray drift.

**Risk Quotients for Mosquito Use (Mosquitomist One and 1.5 U.L.V. Formulations)**
**(ULV Aerial Spray; 0.023 lb ai/A; 1 Application)**
**(Terrestrial EEC's Based on Nomogram; Aquatic EEC's assume 15 % Spray Drift and Water 3 and 6 Feet Deep)**

| Species | Exposure | Toxicity | Risk Quotient |
|---|---|---|---|
| Mammalian Herbivores $LD_{50}$ (15 grams body wt.) | 3.1 - 5.5 ppm | 102 ppm | 0.03 - 0.054 |
| (35 grams body wt.) | | 147 ppm | 0.02 - 0.037 |
| (1000 grams body wt.) | | 647 ppm | 0.005- 0.009 |
| Mammalian Insectivores $LD_{50}$ (15 grams body wt.) | 0.34 - 3.1 ppm | 102 ppm | 0.003- 0.03 |
| (35 grams body wt.) | | 147 ppm | 0.002- 0.02 |
| (1000 grams body wt.) | | 647 ppm | 0.0005-0.005 |

| | | | |
|---|---|---|---|
| Mammalian Granivores $LD_{50}$ (15 grams body wt.)<br>(35 grams body wt.)<br>(1000 grams body wt.) | 0.34 - 3.1 ppm | 462 ppm<br>647 ppm<br>3233 ppm | 0.0007-0.007<br>0.0005-0.005<br>0.0001-0.0009 |
| Mammalian Subacute Dietary $LC_{50}$ | 3.1 - 5.5 ppm | 1330 ppm | 0.002 -0.004 |
| Mammalian Reproduction NOEL | 3.1 - 5.5 ppm | 10 ppm | 0.31 -0.55 |
| Avian Subacute Dietary $LC_{50}$ | 3.1 - 5.5 ppm | 136 ppm | 0.023 -0.040 |
| Avian Reproduction NOEL | 3.1 - 5.5 ppm | 25 ppm | 0.124 -0.22 |
| Freshwater Fish Acute $LC_{50}$ | 0.21 - 0.42 ppb | 1.8 ppb | 0.12 -0.23 |
| Fish Reproduction NOEC | 0.21 - 0.42 ppb | 1.09 ppb | 0.19 -0.39 |
| Aquatic Invertebrate Acute $LC_{50}$ | 0.21 - 0.42 ppb | 0.10 ppb | 2.1 - 4.2 |
| Freshwater Invert. Reproduction NOEC | 0.21 - 0.42 ppb | 0.04 ppb | 5.2 - 10 |
| Estuarine Fish Acute $LC_{50}$ | 0.21 - 0.42 ppb | 0.96 ppb | 0.22- 0.43 |
| Estuarine Fish Reproduction NOEC | 0.21 - 0.42 ppb | 0.28 ppb | 0.75- 1.5 |
| Estuarine Invertebrate Acute $LC_{50}$ | 0.21 - 0.42 ppb | 0.035 ppb | 6.0 - 12 |
| Estuarine Invert. Reproduction NOEC | 0.21 - 0.42 ppb | < 0.0046 ppb | 46 - 91 |
| Estuarine Algae $EC_{50}$ | 0.21 -0.42 ppb | 140 ppb | 0.001-0.003 |

**Risk Summary for Mosquito Adulticide Uses**: Fifteen percent spray drift from chlorpyrifos sprayed aerially as ULV at 0.023 lbs ai/A for adult mosquito control yields risk quotients which exceed the levels of concern for most non-target aquatic animals. Risk quotients do not exceed the levels of concern for non-target terrestrial animals. Risk quotients are mammalian acute (0.0001-0.054), subacute (0.002-0.004), and reproduction NOEL (0.31-0.55), avian subacute (0.023-0.40) and reproduction NOEL (0.12-0.22), freshwater fish acute (0.12-0.23) and reproduction NOEC (0.19-0.39), aquatic invertebrate acute (2.1-4.2) and reproduction (5.2-10), estuarine fish acute (0.22-0.43) and reproduction (0.75-1.5), estuarine invertebrate acute (6.0-12) and reproduction (>46->91), and estuarine algae (0.0015-0.003).

Piscivorous mammals are exposed to estimated residues in the fish viscera of 1.64 ppm and whole fish of 0.56 ppm. These levels are less than the mammalian subacute $LC_{50}$ value of 1330 ppm and less than the mammalian reproductive NOEL of 10 ppm. These residue levels in fish are less than the avian subacute $LC_{50}$ value of 136 ppm and less than the avian reproductive NOEL of 25 ppm.

Risk quotients for non-target aquatic animals in shallow water 0.5 feet deep would be 12 times higher than the reported value in each aquatic category. Shallow waters are important habitats for reproduction of amphibians. Toxicity data indicate that young toad tadpoles are slightly more sensitive to chlorpyrifos than the most sensitive freshwater fish species.

**Risk Summary of All Outdoor Chlorpyrifos Uses**: Application of chlorpyrifos poses acute and reproductive risks to many non-target aquatic and terrestrial animals for all outdoor uses reviewed. The risk quotients for all chlorpyrifos uses exceed the levels of concern for most

terrestrial and aquatic categories. In general, risk quotients are greater among estuarine species, than freshwater species. Terrestrial animals are at less risk than aquatic species. Birds appear to be more at risk than most mammalian species. Aquatic risk quotients for ground spray applications are less than aerial spray applications at the same application rate. Reproductive risk quotients for granular applications are omitted because a standard method is not available, not for the lack of possible risks.

Results from field studies on Iowa corn, California citrus, and Florida golf courses indicate that chlorpyrifos applications adversely affect many types of wildlife. Wildlife casualties which were found on chlorpyrifos-treated sites and tested positive for chlorpyrifos residues include small mammals, birds, snakes, a turtle, adult toads, adult frogs, and tadpoles. Fish kills were found adjacent to both sprayed citrus groves and chlorpyrifos-treated golf courses. These fish kills were found even though none of the field studies included monitoring effects on aquatic animals. Both spray and granular treatments resulted in dead wildlife.

Measured chlorpyrifos residues in some water samples from all three field studies exceed $LC_{50}$ and $EC_{50}$ values for non-target aquatic animals. Measured chlorpyrifos levels in water samples were as high as 486 ppb in the citrus field study, 115 ppb in the corn field study, and 2.55 ppb in the golf course field study. These chlorpyrifos levels found in water adjacent to treated areas certainly exceed the acute and chronic toxicity values for fish (1.8 and 0.96 ppb, respectively) and aquatic invertebrates (0.1 and 0.035 ppb, respectively).

Wildlife incident reports indicate that chlorpyrifos uses around homes, especially treatments associated with termiticide treatments have killed robins and fish. Recent revisions of wildlife incident reports list about 166 incidents of which 92 occurrences have been summarized in the following table. The balance of the 166 incidents have not been reviewed and/or lack adequate details. Termiticide treatments were the most frequently reported type of wildlife incident. In many termiticide incidents, it is unclear if exposures came from indoor, outdoor or perimeter treatments. If the source of exposure from a termite or home use was not reported, it was listed under the "Termiticide: Home" category.

NUMBER OF REPORTED CHLORPYRIFOS WILDLIFE INCIDENTS BY CATEGORY

| Pesticide Use (# of incidents) | Fish | Aquatic Invertebrates | Amphibians | Reptiles | Birds | Mammals |
|---|---|---|---|---|---|---|
| Termiticide: Homes (41) | 31 | 2 | 1 | 1 | 8 | 4 |
| Rodding (5) | 5 | 3 | 2 | | | |
| Perimeter (1) | 1 | | | | 1 | |
| Yard (6) | 4 | | | | 2 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Field crop (3) | 3 | | 1 | | | |
| Citrus (1) | 1 | 1 | 1 | | | |
| Peanuts (3) | 3 | | | | | |
| Soybeans (1) | 1 | | | | 1 | |
| Wheat (1) | 1 | | | | | |
| Corn (1) | 1 | | | | | |
| Golf Course (6) | 4 | | | | 2 | |
| Standing Water (1) | 1 | 1 | 1 | 1 | 1 | |
| Unk. Use (9) | 5 | | | | 4 | |
| Misuse (2) | 1 | | | 1 | | |
| Disposal (3) | 3 | | | | | |
| Spill (7) | 7 | 1 | 1 | 1 | 1 | |
| Total (92) | 72 | 8 | 7 | 4 | 20 | 4 |

Recent bioassay monitoring in the San Francisco Bay area has detected diazinon and chlorpyrifos in discharges from both sewage treatment plants (POTWs) and municipal storm drain systems. Aquatic toxicity of these two organophosphate pesticides appear to be additive. In addition, some toxicity identification evaluations conducted by dischargers, state agencies, and USEPA Environmental Research Laboratory in Duluth, have identified one or both of these pesticides as toxicants in urban discharges in Arizona, Kentucky, Nevada, and Texas (Kolb, 1996).

Bioassay of rainfall samples in Sacramento and San Francisco area show chlorpyrifos residue levels which are toxic to *Ceriodaphnia dubia*, the invertebrate component of EPA's three species bioassay test (Connor, 1996). Measured chlorpyrifos levels in urban runoff exceed lethal levels to aquatic invertebrates in the Calabazas Creek in the Santa Clara Valley (up to 103 ng/L) and tributaries of the Castro Valley Creek (up to 378 ng/L) (Katznelson and Mumley, 1997)

Invertebrate bioassays of aquatic habitats areas adjacent to agricultural areas in the San Joaquin Basin also show chlorpyrifos toxicity. During a year and a half, bioassay study, a 43-mile reach of the San Joaquin River between the confluence of the Merced and Stanislaus Rivers has tested toxic to *Ceriodaphnia dubia* about 50 percent of the time (Foe, 1995). The investigators conclude that the toxicity appears to be caused by pesticides in storm and tailwater runoff from row and orchard crops. Chlorpyrifos was identified more often than any other pesticide as the source of toxicity. The authors determined that there are two seasonal, peak toxicity periods: January-March and April-June. The seasonal peak between January and March occurs during the

rainy season and follows dormant spray applications on stone fruits, apple, pear and almond orchards between December and February. The seasonal chlorpyrifos peak between April and June results from irrigation of alfalfa and sugar beets treated in March to April. Irrigation begins in April. The water flows across the fields in furrows to creeks or collection canals which empty into the river. Irrigation water is flushed from the field in order to prevent toxic salt build-up in the soils. The tailwater is believed to be the primary vehicle responsible for transporting pesticides into surface water.

Reports from recent monitoring studies indicate that chlorpyrifos is also present at lethal levels to *Ceriodaphnia* in the Upper Newport Bay watershed in San Diego (G. Fred Lee and Associates, 1999). "We are finding a variety of pesticides in our samples, some of which seem to be associated with their use at commercial nurseries. As an example, the November 8, 1998 sample of San Diego Creek water in various parts of the Upper Newport Bay watershed showed 670 ng/L of diazinon and 430 ng/L of chlorpyrifos. It also contained several other detected pesticides ..." The chlorpyrifos $LC_{50}$ values for *Ceriodaphnia* and *Mysidopsis*, opossum shrimp are 80 and 35 ng/L, respectively, which yield risk quotients of 5 and 12, respectively. The risks are made even higher by the additive toxicity of chlorpyrifos and diazinon for aquatic species. These monitoring levels portend serious impacts on invertebrate populations these freshwater/estuarine areas.

Widespread contamination of toxic concentrations of chlorpyrifos are cited above in California and reported chlorpyrifos in urban discharges in Arizona, Kentucky, Nevada and Texas. This distribution of chlorpyrifos suggests that the pesticide toxicity problems are widespread, which are also consistent with the widespread low levels of chlorpyrifos in fish discussed earlier. With the exception of termiticide fish kills and some lethal fathead minnow larvae tests, most measurements of chlorpyrifos reported levels in water are high enough that it generally would appear only to effect aquatic invertebrate populations. However, based on chlorpyrifos levels measured in water in the three field studies (486 ppb in citrus, 115 ppb in corn, and 2.55 ppb in the golf course field study), the aquatic exposures for these uses certainly exceed lethal levels for many fish species too.

Application modifications for risk mitigation should consider the following changes. Maximum application rates should be reduced to typical application rates. Spray applications should be limited to ground applications when possible (i.e., eliminate aerial uses where possible). The buffer zones should be enforced for spray drift. Insure that air blast applications are directed away from sensitive areas.

Terrestrial risk quotients are primarily affected by the rates of the individual applications (i.e., risks are reduced, if the total amount applied is spread out over several applications). For multiple applications, terrestrial risk quotients can also be reduced by increasing the minimum time interval between applications, preferably three or even two weeks between treatments. Aquatic risk quotients are most sensitive to the total amount applied per season (i.e., decreasing the application rate or reducing the number of applications can reduce aquatic risks more than increasing the minimum time interval between applications).

**c. Endangered Species Concerns**

Endangered species LOCs are exceeded for small mammals, birds, freshwater fish and invertebrates, and estuarine fish and invertebrates for most chlorpyrifos uses. Chlorpyrifos is used widely throughout the country with a large number of crop and non-crop uses with residues found in 26 percent of fish sampled from 314 monitoring sites. Hence, there is high potential for many endangered and threatened species to be exposed to chlorpyrifos. In two 1981 biological opinions, the Fish and Wildlife Service reviewed the use of 3 formulations (4 EC, 15 G, and 50 W on 12 crops, including tobacco, apples, cole crops, sorghum, peanuts, and corn; and Dursban 10 CR used as a mosquito larvicide. Jeopardy opinions were rendered for a few bird and amphibian species, a snake, and many species of fish and mussels. A third opinion in 1982 for Lorsban 4 EC and 15 G on soybeans, alfalfa, citrus and sunflowers found jeopardy for a few birds, many fish, an amphibian, and several mussels. In all, 105 use limitation determinations were specified for chlorpyrifos uses. Chlorpyrifos is included in a 1993 draft opinion on many chemicals for a number of crops. Conclusions in the draft suggest that some species may be in jeopardy. Jeopardy opinions were made for a few birds, many fish, a few amphibians, and many freshwater mussels. At present, several voluntary use limitations have been made.

The Agency has developed a program (the Endangered Species Protection Program) to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will eliminate the adverse impacts. At present, the program is being implemented on an interim basis as described in a Federal Register notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future Federal Register notice. The Agency is not imposing label modifications at this time through the RED. Rather, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program.

**d. Uncertainties in the Risk Assessment**

Several areas of uncertainty have been identified in the above summary sections. Significant areas of uncertainty include:

1) For some uses, the extent of cumulative risks from multiple applications methods and use rates was asssessed independently, when applications methods or time between applications differ. In those cases, the GENEEC Model can not intergrate the different application methods or variable timings. Hence, combined risks for maximum label use were not assessed. In order to estimate the maximum risks permitted by label uses, exposures for all applications should be jointly assessed for terrestrial and aquatic habitats.

2) Weight loss and reduced food consumption observed in avian dietary tests suggest that

chlorpyrifos could be distasteful or repellant to birds or that the reduced food consumption is the result of sublethal effects which causes the sick birds to become lethargic and reduce all activities including feeding. Avian deaths in the corn, citrus, and golf course field studies and wildlife incidents indicate that, if repellency exists, it is not sufficient to prevent the death of birds, small mammals, and snakes.

3) The number of species susceptible to poisoning and the extent to which wildlife may consume lethal amounts of chlorpyrifos-treated granules. Results from the field studies are unclear, because few carcasses were analyzed for chlorpyrifos. Out of 17 carcasses collected in the corn study only three were analyzed and only a short-tailed shrew tested positive for chlorpyrifos (2.1 ppm). In the golf course study, 11 carcasses were collected, but only a Florida soft-shell turtle was analyzed and the turtle tested positive for chlorpyrifos (1.09 ppm).

4) As a highly toxic organophosphate, chlorpyrifos, reentry periods are specified for many crops for human health concerns. It is uncertain what adverse effects may likewise occur to wildlife from inhalation and dermal adsorption. Most animals in a treated field are found on the ground or perched on treated vegetation and would be closer to chlorpyrifos residues than farm workers. From observations made during the field studies, it is apparent that some animals show signs of cholinesterase inhibition in birds and mammals. It is uncertain to what degree cholinesterase inhibition may cause death or modify an animals' behavior and its ability to avoid predators. High predation is suggested by the numerous feather spots and partial carcasses were found during carcass searches in the corn study. High chlorpyrifos impacts on terrestrial wildlife are suggested by the ten cases where carcasses were analyzed for chlorpyrifos or cholinesterase inhibition were observed in the corn field study; 60 percent of the animals were confirmed as exposed to chlorpyrifos.

5) Reproductive risks to freshwater fish may be as much as 2 orders of magnitude higher than the fathead minnow reproductive value used in this assessment. In the range of acceptable fish acute toxicity values, the fathead minnow acute $LC_{50}$ value is the least sensitive fish species out of six freshwater fish species. The fathead minnow acute $LC_{50}$ value is 203 ppb versus an acute $LC_{50}$ of 1.8 ppb for bluegill sunfish, the most acutely senitive freshwater fish species. Using an acute-to-chronic ratio for these two species, the NOEC for bluegill sunfish is estimated to be 0.005 ppb (i.e., fathead minnow: $LC_{50}$ 203 ppb / NOEC 0.57 ppb = bluegill: $LC_{50}$ 1.8 ppb / NOEC; X = 0.005 ppb).

6) EECs used for estuarine species were the same as for a farm pond. While both areas act as a sink for chemical residues, the tidal flushing in estuarine areas may reduce water concentrations by dilution. On the other hand, the upper reaches of most estuarine areas are shallow water and if the tide is out when the runoff reaches the water, estuarine organisms will be exposed to higher concentrations than for those in the farm pond.

7) Risks to benthic organisms could not be assessed for lack of sediment toxicity data, even though chlorpyrifos is expected to mainly partition to sediments. Sediment toxicity test data are unavailable for chlorpyrifos.

8) Biomonitoring data in California have shown toxic levels of chlorpyrifos in POTW effluents, rainfall, and 43-miles of the San Joaquin River in agricultural areas. Other states have also identified problems with toxic levels of chlorpyrifos in POTW effluents. The geographic extent of these problems are unknown. The extent of adverse effects can not be assessed, because the levels of chlorpyrifos were not analytically measured.

9) Results from a national fish residue study show chlorpyrifos in 20 percent of the fish sampled, it is uncertain whether the exposures are sufficient to adversely affect aquatic organisms. The widespread occurrence of chlorpyrifos in fish tissues and the extent of lethal chlorprifos levels in California suggest that chlorpyrifos may be a nationwide concern for aquatic organisms.

10) Aquatic risks have not been assessed for a myriad of aquatic habitats, such as marshes, streams, creeks, and shallow rivers, intermittent aquatic areas, etc., which are more extensive and are frequently more productive than 2-meter deep ponds. Risks to aquatic species in these shallow aquatic habitats are likely to be considerably greater than for organisms in a 2-meter deep pond (i.e., 6 to 13 fold higher risk quotients). Shallow water areas provide habitat for a diversity of aquatic organisms which are distinct from species found in deeper ponds or are only found in the shallow margins. For example, amphibians such as tadpoles and newts may spawn and develop in temporary, shallow pools of water. Bluegill sunfish typically spawn and fry inhabit the edge of ponds in water depths of 1 to 3 feet.

11) The extent to which chlorpyrifos and other pesticides might be responsible for the worldwide decline in populations of amphibians is not known. Toxicologists generally consider fish to be more sensitive to pesticides than amphibians, but such is not the case with chlorpyrifos. The reported $LC_{50}$ for tadpoles is about 1 ppb versus 1.8 ppb for the most sensitive fish species, bluegill, hence the risk quotients for fish would be considerably greater, about 20 fold, for tadpoles in 6-inch aquatic habitats (i.e., 12 (6-inch veersus 2-meter water depths) X bluegill $LC_{50}$ 1.8 ppb / tadpole $LC_{50}$ 1 ppb). Reported deaths of adult frogs and toads in the chlorpyrifos field studies and wildlife incidents suggest that these species may be sensitive to dermal exposures. Amphibians have skin which must be kept moist that may be more sensitive to dermal exposures than insects, fish, turtles, snakes, birds, and mammals. Chlorpyrifos exposures would appear to pose a potential risk to amphibians in both the terrestrial and aquatic habitats.

12) Chlorpyrifos-related deaths of snakes observed in the field studies indicates secondary toxicity to predators, which would increase the number of wildlife species of concern to carnivorous mammals, birds, turtles, and snakes. The extent of risk to carnivorous species is depent on their sensitivity and the amount of chlorpyrifos present in the dchlorpyrifos-poisoned animal.

13) The extent of additive toxicity to aquatic species of chlorpyrifos with diazinon and other organophosphate insecticides (Bailey *et al*., 1997 and Huang, Fujimura and Finlayson, 1994). Chlorpyrifos has also been found to be synergistic with atrazine, a widely used herbicide applied preplant to corn about the same time as the predominant chlorpyrifos use on corn (Pape-Lindstrom and Lydy, 1997). The presence of other pesticides and their combined toxicity with

chlorpyrifos is a quantitative problem based on the proximity of other treated crops and the timing of their use with respect to chlorpyrifos applications. Certainly the proximity of pre-plant uses of atrazine and chlorpyrifos uses on corn are frequent events. Re-testing without DMSO and with much lower atrazine concentrations has been completed and shows synergism with OPs, but the new data are not yet available (i.e., has not yet been published).

### e. Comparison of Risks to Alternative Pesticides

Chlorpyrifos risks were compared to other major pesticides for some major crop uses. LOC values were obtained for typical use rates for granular formulations for a single application. Tables showing the comparative risks are attached as an Appendix. The results indicate that chlorpyrifos usually have the second or third highest risk quotients among select insecticides to terrestrial species and first or second highest risk quotients for select insecticides to aquatic species for the select list of highly toxic insecticides.

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